SD421.32
.P3
S64
1981

Forest Service

**Pacific Northwest Region**

**Aviation and Fire Management**

# Users' Guide to Debris Prediction and Hazard Appraisal

WESTFORNET
MONTHLY ALERT
Edition JUN 1982
Item No. 110
File SD 421.32 P3 S64

## PACIFIC NORTHWEST REGION

Revised, August, 1981

Property of
National FS Library
USDA Forest Service
240 W Prospect Rd
Fort Collins CO 80526

## Errata Sheet

Please make the following changes in the Users' Guide to Debris Prediction and Hazard Appraisal, Revised August, 1981.

On the second page of the document below the Preface, change the address for Don Carlton to Mt. Hood National Forest, 2955 NW Division, Gresham, Oregon, 97030 and the phone number to 503-221-2085.

On the fourth page of the document under Authors, change the location of Don Carlton to the Mt. Hood National Forest, Gresham, Oregon.

On pages 21 and 22, all diamond symbols (◆) are the same as an asterisk (*) on the keyboard of the computer terminal.

# USERS' GUIDE TO DEBRIS PREDICTION AND HAZARD APPRAISAL - PACIFIC NORTHWEST REGION

BY:

J. A. Kendall Snell
R. Gordon Schmidt
John D. Dell
Donald W. Carlton

ADAPTED FROM:

Users' Guide to Debris Prediction and Hazard Appraisal.
USDA, Forest Service, Northern Region (R-1), Missoula, Montana
37pp., illus. revised January, 1979

BY:

John V. Puckett
Cameron M. Johnston
Fire and Aviation Management,
Northern Region (R-1)

and

Frank A. Albini
James K. Brown
David L. Bunnell
William C. Fischer
J. A. Kendall Snell

Northern Forest Fire Laboratory
Intermountain Forest and Range Experiment Station

R6 A&FM 071 1981

USDA - Forest Service
Pacific Northwest Region (R-6)
Portland, Oregon

August 1981

## PREFACE

This USERS GUIDE was adapted directly from the Northern Region's Users Guide. A number of adjustments have been made to allow use of the Debris Prediction and Hazard Appraisal system with Region 6 timber types.

Much of the written material herein is a duplication of the text in the Region 1 Users Guide to Debris Prediction and Hazard Appraisal. Certain changes in text and format have been inserted throughout for applicability to our Region's stand exam procedures. Debris prediction regression equations were developed for Region 6 timber types and supplement those of Region 1.

The section on Fuel Inventory has been added to provide a uniform procedure for Region 6 users. Most of the work on this part of the guide was done by R. Gordon Schmidt.

Before information is gathered as an input to the decision-making process, an analysis of the accuracy and extent of the informational needs must be made. Throughout this Users' Guide, emphasis is placed on the accuracy of the predictions. The accuracy must be considered when determining the data collection methods to be employed. There is no advantage to gathering a lot of information not needed, or with much greater accuracy than is warranted.

For assistance with any phase of this Users' Guide, contact Don Carlton, Clackamas Ranger District, Ripplebrook Ranger Station, Estacada, Oregon, 97023; phone, (503) 834-2275.

## ACKNOWLEDGEMENTS

The authors wish to acknowledge Cameron Johnston, Fire and Aviation Management, Region 1, for his assistance and review. We also want to thank Frank Albini, Jim Brown, David Bunnell, William Fischer, and Jack Puckett for making their material so readily available to us.

TABLE OF CONTENTS


| | Page |
|---|---|
| INTRODUCTION | 1 |
| I. FUEL INVENTORY | 3 |
| Options for Estimating Downed Woody Material | 3 |
| Procedures for Data Collection | 4 |
| Forest Residues Photo Series Method | 4 |
| Planar Intersect Method | 4 |
| Calculations for Planar Intersect | 9 |
| Graphical Aids | 9 |
| Hand Calculations | 10 |
| Computer Method | 10 |
| Sampling Error | 16 |
| II. OBTAINING DEBRIS PREDICTIONS - DEBMOD6 | 18 |
| Uses of Debris Prediction | 19 |
| Acquiring the Debris Printouts | 20 |
| Debris Prediction Definitions | 25 |
| Other Debris Prediction Methods | 25 |
| Accuracy of Debris Predictions | 26 |
| Summarizing Debris by Cutting Prescription | 27 |
| Information Obtained from Cutting Prescription | 27 |
| Example of Summarizing Potential Debris | 28 |
| III. HAZARD APPRAISAL | 31 |
| Uses of Fire Behavior Prediction | 32 |
| Completing the Slash "Hazard" Form | 33 |
| Explanation of "Hazard" Appraisal Output | 37 |
| Fuel Output | 37 |
| Fire Behavior Output | 39 |
| Assumptions and Accuracy | 44 |
| Basic Assumptions | 44 |
| Accuracy of Predictions | 45 |
| HAZARDS ADP Program Writeup | 48 |
| High Speed Terminal | 48 |
| Low Speed Terminal | 48 |
| REFERENCES | 53 |
| APPENDIX I Table of Random Azimuths | 55 |
| APPENDIX II Sources for DEBMOD Modifications for DEBMOD6 | 56 |
| APPENDIX III Densities of Common Western Tree Species | 57 |
| APPENDIX IV Key Punching Instructions for High Speed Terminal | 58 |
| APPENDIX V Sample Forms | 62 |

## AUTHORS

J. A. Kendall Snell is a Research Forester with the Forest Residues and Energy Program, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon. He was formerly a Research Assistant at the Northern Forest Fire Laboratory, Missoula, Montana.

R. Gordon Schmidt is a Forester with the Forest Residues and Energy Program, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon. He formerly was Fire Management Officer on the Columbia Gorge Ranger District, Mt. Hood National Forest.

John D. Dell is Regional Fuels Management Specialist, Aviation and Fire Management, Pacific Northwest Region, U.S. Forest Service.

Donald W. Carlton is a Forester in Fuels Management on the Clackamas Ranger District, Ripplebrook Ranger Station, Mt. Hood National Forest, Estacada, Oregon.

## List of Figures


| Figure | Title | Page |
|---|---|---|
| 1a | Fuel Inventory Cover Card | 7 |
| 1b | Fuel Inventory Plot Card | 8 |
| 1c | Data File Creation - FCCC | 12 |
| 1d | Fuel Inventory Output - FCCC | 13 |
| 1e | Fuel Inventory Output - FCCC | 14 |
| 1f | Fuel Inventory Output - FCCC | 15 |
| 1g | Graph of Percent Error vs Number of Sample Points | 16 |
| 2a | Debris is Generated From Different Parts of a Tree | 19 |
| 2b | Stand Examination Cover Card | 20 |
| 2c | DEBMOD6 Printout | 30 |
| 2d | Debris Potential Summary Form | 30 |
| 3a | Slash Hazard Data Form | 36 |
| 3b | Activity Fuel Computer Output | 38 |
| 3c | Untreated Slash--Potential Fire Behavior | 42 |
| 3d | Lopped Slash--Potential Fire Behavior | 43 |


## List of Tables


| Table | Title | Page |
|---|---|---|
| 2a | Tree Species vs Function Used for Debris Prediction | 18 |
| 2b | Contribution of Debris for Tree History Codes | 26 |
| 2c | Actual Defect Percentages Used in DEBMOD6 | 26 |

# INTRODUCTION

## INTRODUCTION

The objective of this Users' Guide is to explain procedures necessary to obtain and use weight estimates of down woody debris and predicted debris (from standing trees), and how to obtain a wildfire behavioral assessment of this debris for proposed harvesting and thinning activities. When used and interpreted properly, these procedures will give forest managers a more objective means in which to assess the wildfire management implications of debris before it is created. It will yield evidence that can be used to support decisions made in Environmental Assessment Reports (EAR), Brush Disposal (BD) appraisals and plans, and silvicultural thinning prescriptions. The procedures used to obtain estimates of debris and wildfire behavior are discussed in three separate sections:

Section I: FUEL INVENTORY
-estimating weights and volumes of downed woody material on a site prior to harvest.

Section II: OBTAINING DEBRIS PREDICTIONS - DEBMOD6
-predicting debris from standing trees for proposed activity areas.

Section III: HAZARD APPRAISAL
-combining the weight estimates from Sections I and II to make wildfire behavior predictions.

The procedures are discussed separately only for clarity. However, to obtain the maximum utility of these procedures the user must learn to integrate them.

Procedures necessary to obtain estimates of dead and down woody fuels are not new. The two common ones used within National Forest Systems are the planar intersect method (Brown, 1974), and the forest residues photo series (Maxwell and Ward, 1976). Many forest managers have become confused on when to use one or the other. Clarification of when to use these methods and alternative calculation methods for planar intersect are discussed in Section I.

A computer program--called DEBMOD6--has recently been completed for Region 6. This program makes it possible for land managers to easily predict oven dry tree crown and bole cull weights before trees are cut. DEBMOD6 is commonly referred to as a debris prediction program, and is intended to be used with site specific data. No additional field data collection is required if a silvicultural stand examination 1/ has been completed for the stand in question. When the stand exam data is edited and processed, a data tape is created. The DEBMOD6 program uses these data. The procedures necessary to obtain a debris prediction are discussed in Section II.

1/ Refer to the R-6 Silvicultural Examination and Prescription Handbook (Chapter 40-Stand examination), Division of Timber Management, USDA, Forest Service, Portland, Oregon (April, 1974)

The debris prediction program sums the crown and bole cull weights of all trees to a per acre basis to reflect the amount of debris one could expect to create from a clearcut harvesting prescription. However, by using procedures discussed in Section II, DEBMOD6 output can be reduced to reflect any cutting prescription.

Section III describes how to combine the down woody debris estimated in Section I with the predicted debris from Section II, and how to submit this combined debris to a wildfire appraisal computer program called--HAZARD. The HAZARD program was developed at the Northern Forest Fire Laboratory and is available for national use. It is currently kept at Fort Collins Computer Center (FCCC). The HAZARD program printout contains fire behavior parameters that reflect potential wildfire conditions that could be created if proposed harvesting or thinning prescriptions were followed. <u>These fire behavior parameters reflect only wildfire situations and should not be used for prescribed burning plans</u>.

The HAZARD program provides the option for the user to enter time-lag fuel moistures or the program will automatically assign them. Care should be used in specifying these values because the program is sensitive to them. A qualified Fire Behavior Officer with recent training in the National FBO Course would be helpful in selecting proper time-lag fuel moistures.

Both the Debris Prediction Program--DEBMOD6--and the wildfire behavior appraisal program--HAZARD--print out numerical values. These values must not be interpreted as absolute, rather they should be used to reflect relative differences between activity areas, types of activities, or intensity of activities. When these values are used along with the land managers experience and knowledge, very sound and defensible decisions about fire and fuel management can be made.

# SECTION I

# FUEL INVENTORY

## I. FUEL INVENTORY

To obtain weight estimates of total down woody fuels that can be expected after harvesting or thinning, a pre-activity down woody inventory must be completed and added to predicted values. The predicted values will be discussed in Section II of this Users' Guide. Hazard appraisal can then be estimated from this estimated total fuel complex (refer to Section III).

### OPTIONS FOR ESTIMATING DOWNED WOODY MATERIAL

There are two methods available for obtaining on site weight and volume estimates of downed woody material prior to management activities. They are:

1. Forest Residues Photo Series-Natural (Maxwell and Ward, 1980) and Activity (Maxwell and Ward, 1976).
2. Planar Intersect (Brown, 1974)

The planar intersect technique is a much more labor intensive technique than the forest residue photo series. Therefore, use of the planar intersect technique should be limited to areas where detailed site specific fuel information is needed. Four examples of when to use the planar intersect method are:

1. In training Fuel's Specialists so they can make visual fuel amount estimates with confidence.
2. Making size class estimations for residue utilization purposes.
3. Contract inspections.
4. In constructing photo series.[2/]

The forest residues photo series may be used in all other cases with satisfactory results.

[2/] See instructions for constructing a photo series in: National Fuel Classification and Inventory System - Preliminary Draft. USDA, Forest Service (Part 1-Fuel Classification, 23 pp., illus.) Washington, D.C. August, 1974.

## PROCEDURES FOR DATA COLLECTION

### FOREST RESIDUES PHOTO SERIES METHOD

The Photo Series for quantifying natural and activity forest residues include detailed instructions on their use for inventory, determination of desired levels, and prediction of residues. (See footnote 2).

### PLANAR INTERSECT METHOD

Data will be collected as outlined in the Handbook for Inventorying Downed Woody Material by Brown (1974). All steps outlined in Brown's Handbook will be followed in inventorying fuels except:

A. Step 6, page 7 (refer to Brown 1974). This step should be omitted because the HAZARD program estimates the depth of the original ground fuels plus the added activity fuels.

B. Figure 12, page 14 (refer to Brown 1974). To facilitate using the R-6 Dead and Down Woody Material computer program, (described later) this data form is replaced by a Region Six fuel inventory plot card (Figure 1b).

Some Regional variations exist with inventorying procedures. They are:

A. Step 2, page 4 (refer to Brown 1974). Any random method may be used to determine the direction of the sampling plane. A table of random AZIMUTHS may be used. (See Appendix I for table).

B. Steps 8 and 9, pages 8 and 9 (refer to Brown 1974). Region 6 has developed a computer program which calculates Step 9 for you but requires that you enter the diameters over 3 inches by species at Step 8. Region Six fuel inventory field forms reflect this change. (Figures 1a and 1b).

## Field Forms

Region Six has developed the forms necessary for recording downed wood field data. They are shown in Figures 1a and 1b. Figure 1a, the Fuel Inventory Cover Card, is completed once for each area being inventoried. This card provides the proper identification for the area so that it may be entered into the T.R.I. System. Figure 1b, the Fuel Inventory Plot Card, is completed for each plot taken within the sample area.

Both forms have been arranged so that computer key punching is facilitated.

## Fuel Inventory Cover Card (Figure 1a)

The first line of data on the Cover Card requires two blanks indicated by ⱥⱥ on the card. Next are 20 columns which may be used for the unit name or some other identifying name. Four other columns are available for a unit number, and four more for the size of the area being sampled in acres.

The next line of data begins with two blanks and records T.R.I. identification for the area. In addition to this one line, you can have up to three more lines with extra reference T.R.I. data. These lines are optional and will not be key punched if nothing is entered. Note that these extra lines begin with an xⱥ on the card rather than two blank (ⱥⱥ) columns.

The sixth line begins with two blanks (ⱥⱥ) followed by eight columns for recording the date of the survey. Next are twenty columns for recording the surveyor's name.

The seventh line requires an "age class" code which depicts the age of the fuels you are sampling.

Age Class 1 is used for natural stands which have no created activity fuels associated with them. If this code is used leave percent needles retained blank because the program assumes no needle retention.

Age Class 2 indicates fresh activity fuels less than one year old. If this code is used leave percent needles retained blank because the program assumes 100% needles retained.

Age Class 3 indicates activity fuels older than one year and assumes 100% retention of needles and will always give you 100% needle loading. If this code is used leave percent needles retained blank.

Age Class 4 indicates activity fuel older than one year but requires you to enter the estimated percent of needles retained on the twigs. Estimates may range from 0-99% and must be right justified (i.e., 5 percent needles retained is recorded as 05). Estimate needles retained to nearest whole percent.

Line Lengths are specified next. These may vary from one area to the next, but once the line lengths have been determined for a sample area, they must not be changed.

Size class entries cause the output from the inventory data to be sorted into these classes. The default values are 3-8 inches, 8-20 inches, and 20+ inches. You may vary these if you desire. To use your own size classes greater than 3 inches in diameter, enter the largest diameter of the size class in the space provided. For example, if you wish to use values 3-6 inches, 6-10 inches, 10-20 inches; enter 6, 10, 20, 0 (see Figure 1a). If you plan to input the data to HAZARD, you must use the size classes 3-6, 6-10, 10-20, and 20+.

Downed Fuel Inventory Plot Card (Figure 1b)

This card is simple in design and is completed once for each plot, similar to a timber cruise plot card or stand exam plot card.

The first line indicates the plot number and percent slope of the sample plane. It begins with a P as shown on the card, and P001015 would indicate Plot 1 with 15% slope of the sample line.

The second line of data is the total fuel particle count for each fuel size class less than 3 inches. 038005005 would show thirty-eight 0-1/4 inch particles counted, five 1/4-1 inch particles counted, and five 1-3 inch particles counted.

The third line of data begins with the entry of species codes. These codes are listed on the cover card and correspond to standard Region Six timber species codes. A code of 999 indicates the particle is rotten. If you have six species, the computer will lump your fifth and sixth species together and print you a message that it has done so.

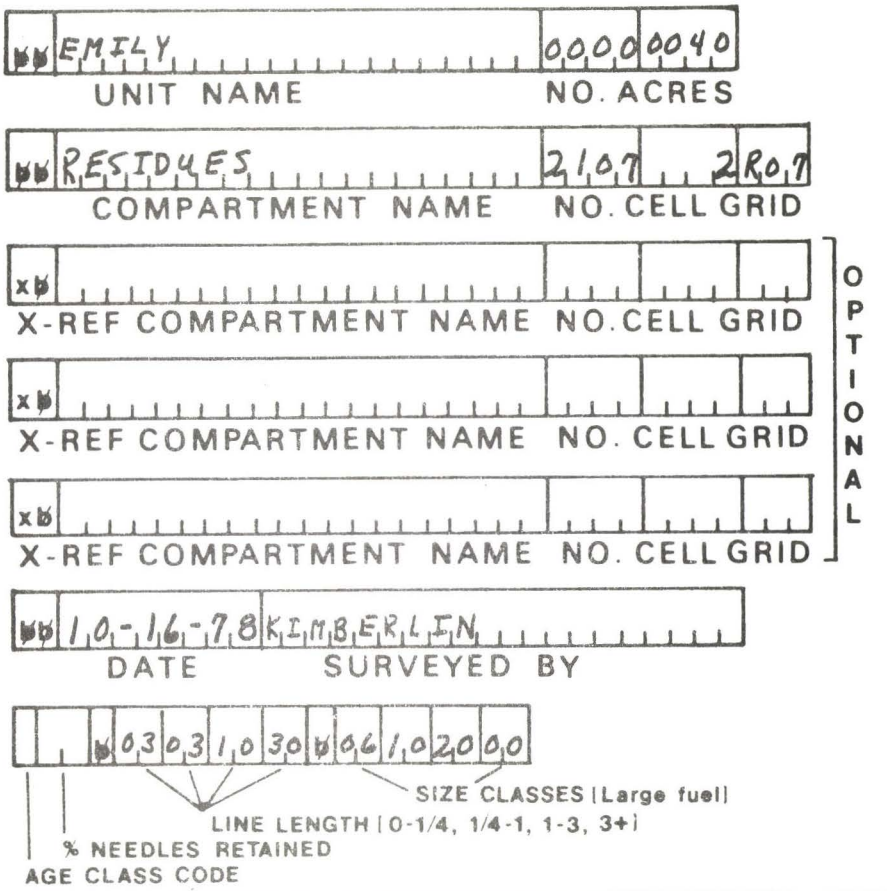
The recorded diameters corresponding with the species code are entered across the page. If you have more entries than columns on the form simply start another line with the same species code.

The next data entered are the optional fuel bed depths. Three measurements are entered. As stated earlier, it is not recommended this step be taken since the HAZARD program already estimates fuel depths. For those who do decide to take fuel depth measurements, entries are made to the nearest whole inch. The line is first identified with three 0's and a blank (␣) (already entered on card). 000␣261503 indicates three slash depths of 26 inches, 15 inches and 3 inches respectively. If no slash depths are taken enter zeroes.

Duff depths are entered in the same format as fuel bed depth, except only two entries are made. The entries are to the nearest 1/10 inch. The line is first identified with three 0's and a blank (␣) (already entered on the card). 000␣018012 indicates duff depths of 1.8 inches and 1.2 inches. Note that the decimal point is NOT entered on the Cover Card.

USDA-FOREST SERVICE **REGION 6**

# FUEL INVENTORY COVER CARD




AGE CLASS CODES:

1 = NATURAL  2 = FRESH  3 = 1 YR PLUS

4 = 1 YR PLUS (Enter % of NEEDLES RETAINED)

SPECIES CODES:

| | | |
|---|---|---|
| 081-ICEDAR | 015-WHITE FIR | 098-SITKA SPRUCE |
| 041-PO CEDAR | 263-W HEMLOCK | 431-CHINKAPIN |
| 242-WR CEDAR | 264-M HEMLOCK | 361-MADRONE |
| 204-DOUG FIR (INLAND) | 070-W LARCH | 631-TANOAK |
| 205-DOUG FIR (COAST) | 108-LODGEPOLE PINE | 351-RED ALDER |
| 017-GRAND FIR | 122-PONDEROSA PINE | 310-VINE MAPLE |
| 022-NOBLE FIR | 117-SUGAR PINE | 888-MIXED |
| 011-SILVER FIR | 119-WHITE PINE | 999-ROTTEN |
| 019-ALPINE FIR | 093-ENGLE SPRUCE | |

R6-5150-126 (6/79)

Caution: On some copies of this form, the species codes for Tanoak and Red Alder are wrong. The form above has the correct codes.

Figure 1a

USDA-FOREST SERVICE **REGION 6**

# FUEL INVENTORY PLOT CARD

UNIT NAME Sample UNIT NO.____ SURVEY____

| P,0,0,1 | 0,1,5 % |
|---|---|

PLOT NUMBER AND SLOPE (%)

| 0,3,8 | 0,0,5 | 0,0,5 |
|---|---|---|
| 0-1/4 | 1/4-1 | 1-3 |

PARTICLE COUNT

| SPP. | | RECORDED DIAMETERS | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0,1,7 | ✗ | 0,9 | 2,1 | 0,8 | | | | | | | | | | |
| 9,9,9 | ✗ | 1,5 | | | | | | | | | | | | |
| | ✗ | | | | | | | | | | | | | |
| | ✗ | | | | | | | | | | | | | |
| | ✗ | | | | | | | | | | | | | |
| | ✗ | | | | | | | | | | | | | |
| | ✗ | | | | | | | | | | | | | |
| | ✗ | | | | | | | | | | | | | |
| | ✗ | | | | | | | | | | | | | |
| | ✗ | | | | | | | | | | | | | |

| 0,0,0 | ✗ | 2,6 | 1,5 | 0,3 |
|---|---|---|---|---|

FUEL BED DEPTH (inch)

| 0,0,0 | ✗ | 0,1,8 | 0,1,2 |
|---|---|---|---|

DUFF DEPTH (1/10 inch)

R6-5150-126a (6/79)

Figure 1b

## CALCULATIONS FOR PLANAR INTERSECT

There are three separate methods for reducing the planar intersect field data to fuel loading. They are graphic aids, hand calculations, and use of a computer.

Calculation procedures for programmable calculators are available for the Wang 720 and the Hewlett Packard HP-97/67. Copies of these programs are available from the Regional Office. They are not discussed here because many variations exist and many other models of calculators can also be programmed for fuel inventory calculations.

### GRAPHICAL AIDS

Anderson (1978) presented an easy technique for estimating fuel loadings in the field. Assumptions made in constructing the graphs in "Graphic Aids for Field Calculation of Dead, Down Forest Fuels," will apply to Region Six. Therefore, this guide provides graphic aids that are completely satisfactory for use in this Region.

## HAND CALCULATIONS

The Hand Calculation Method should rarely be necessary because of the availability of computer programs and graphic aids. However, it is important to be familiar with this method because it illustrates the calculation used in developing other methods of computation. The handbook for inventorying downed woody material by Brown (1974) explains the procedures for hand calculation.

## COMPUTER METHOD

Fort Collins Computer Center (FCCC) currently maintains a computer program for Region 6 which can be used to reduce fuel inventory data. The program was developed by Gordon Schmidt and Dennis Pendleton and programmed by Elmer Larsen.[3/] The program operates in batch mode and allows input from Region 6 down woody field forms (figures 1a and 1b) for any number of sample points taken in conjunction with the Handbook for Inventorying Downed Woody Material (Brown 1974). The program produces a detailed summary report of fuel loading by size class and by species.

### Data Input

The program is designed to operate in batch mode rather than an interactive mode. Therefore a data file must be constructed before the program is executed. The data file is quite easily constructed from the Cover Card (Figure 1a) and the Plot Card (Figure 1b). These field cards have been designed for ease in constructing this data file. The data file format simply consists of entering the Cover Card information line by line followed by entering the Plot Card(s) line by line until all sample points have been completed. The last entry in the data file must be an end statement.

### Data Processing

Current Fort Collins Computer Center procedures for access are available from your Forest Computer Specialist. You should contact the Computer Specialist and design a procedure for submitting the field data cards, key punching, program execution, and output routing for your Forest use.

The following runstream should assist you in using FCCC. Refer to the down woody forms (figures 1a and 1b) and the executed runstream (figure 1c) for a completed example.

3/ Dennis Pendleton is the District Fuel Manager, North Bend Ranger District, Mt. Baker-Snoqualmie National Forest. Elmer Larsen is a computer programmer assigned to the Regional Office in Portland.

## RUNSTREAM FOR FORT COLLINS COMPUTER CENTER (FCCC)

TO BUILD THE DATA FILE AND RUN THE PROGRAM AT FCCC
NOTE: The operators response to the computer prompts (<) are underlined.

Dial FCCC phone number

Enter your terminal site ID

*UNIVAC.....etc.

>@RUN R06iii,1106ff--------,FLI6ffuu,S05
(Replace iii with your initials, ff with Forest number, '-' with the remainder of your account number, and uu with your unit number. See your computer specialist for help).

*DATE 042577 TIME 110445 (Computer Logon)

>@ASG,CP --------. (Enter a name to identify your data file).

READY

>@ED,I --------. (Enter data file name again).

CASE UPPER ASSUMED
ED 15R2 -THU.....etc.
INPUT
1i:>_____ (Enter plot sampling data from inventory cards. See figures 1a, 1b, and 1c. You should work with your computer specialist to learn how to build and correct this data file with the text editor).

>EXIT

xxx LINES FIELD DATA

>@XQT FLI6*FUEL.FLI-INVENT

FUEL INVENTORY PROGRAM (VER 02-17-78)
DOWNED WOODY MATERIAL

ENTER DATA FILE NAME
>--------. (Program will call and use your file)

The report will be printed, see figures 1d, 1e, and 1f.

>@FIN

Accounting information will be printed

>@@TERM (Computer Logoff)

This completes your computer run

```
L@TR
@RUN R06AJW,110652        ,IP??vUNJAV:Ja:
*UQ
*NO RUN ACTIVE*
@RUN R06AJW,1106          ,PNW
DATE: 040479  TIME: 094609
AN ELECTRONIC MAIL SYSTEM IS NOW AVAILABLE ON THE FCCC SYSTEM.  IT IS
CALLED DISPATCH.  FOR DETAILS ISSUE @INFO,L  ,DISPATCH,79-00022
>@ASG,CP EMILY.
READY
>@ED,I EMILY.
CASE UPPER ASSUMED
ED 15R2-NED-04/04/79-09:47:38-(,0)
INPUT
1I:>  EMILY                    00010040
2I:>  RESIDUES                 2107   2P07
3I:>  10-16-78KIMBERLIN
4I:>1   03031030 03061020
5I:>P001015
6I:>038005005
7I:>017 091208
8I:>999 15
9I:>000 261503
10I:>000 018012
11I:>P002004
12I:>019001005
13I:>017 0811
14I:>000 021316
15I:>000 044020
16I:>P003010
17I:>012003004
18I:>070 06
19I:>999 04
20I:>000 020201
21I:>000 038016
22I:>P004010
23I:>008001001
24I:>000 010200
25I:>000 008010
26I:>P005010
27I:>009002004
28I:>017 1910
29I:>000 000102
30I:>000 024002
    :
    :
    :     (PLOTS  6 THROUGH 24 DELETED FOR BREVITY)
    :
    :
125I:>P025005
126I:>021001001
127I:>999 07
128I:>000 010006
129I:>000 012000
130I:>END
0:>EXIT
```

Figure 1c

```
@SYS$ FUEL*FUEL.FLI-INVENT

FUEL INVENTORY PROGRAM     (VER. 03-01-79)
DOWNED WOODY MATERIAL

ENTER DATA FILE NAME
>EMILY.
```

FUEL INVENTORY RECORD
DOWNED WOODY MATERIAL

PROJECT NAME: EMILY  COMP NO: 2107  CELL NO: 2R07

| | ------TONS/ACRE------ | | | | | | |
|---|---|---|---|---|---|---|---|
| PLOT | 0 ---- 1/4 | ---- 1 | ----- 3 | ----- 6 | ----- 10 | ----- 20 | |
| 001 | 1.22 | 3.07 | 7.34 | .00 | 21.05 | 47.39 | .00 |
| 002 | .60 | .61 | 7.27 | .00 | 9.20 | 17.38 | .00 |
| 003 | .38 | 1.83 | 5.84 | 9.17 | .00 | .00 | .00 |
| 004 | .25 | .61 | 1.46 | .00 | .00 | .00 | .00 |
| 005 | .29 | 1.22 | 5.84 | .00 | .00 | 66.51 | .00 |
| 006 | .67 | 1.22 | 1.45 | .00 | 17.35 | .00 | .00 |
| 007 | 1.24 | 1.83 | 7.27 | 5.05 | 7.46 | .00 | .00 |
| 008 | .66 | 2.43 | 2.90 | .00 | .00 | 16.76 | .00 |
| 009 | .73 | 6.09 | 1.45 | 10.22 | .00 | .00 | .00 |
| 010 | .06 | .61 | 2.91 | .00 | .00 | .00 | .00 |
| 011 | .70 | 1.22 | 1.45 | .00 | 5.70 | .00 | .00 |
| 012 | 1.27 | 3.04 | 2.91 | .00 | .00 | 20.70 | .00 |
| 013 | 1.68 | .61 | 2.91 | .00 | 11.64 | .00 | .00 |
| 014 | .19 | .61 | .00 | 1.86 | .00 | .00 | .00 |
| 015 | .19 | .61 | 4.36 | .00 | .00 | .00 | .00 |
| 016 | .51 | 1.23 | 1.47 | .00 | .00 | .00 | .00 |
| 017 | .70 | 1.23 | 1.47 | .00 | .00 | 37.16 | .00 |
| 018 | .89 | 1.83 | 7.30 | .00 | .00 | .00 | .00 |
| 019 | .51 | 4.26 | 5.82 | .00 | 7.04 | .00 | .00 |
| 020 | 1.33 | 3.65 | 1.45 | 5.05 | 7.46 | .00 | .00 |
| 021 | .54 | .61 | 1.46 | 2.31 | .00 | .00 | .00 |
| 022 | .41 | .00 | 2.91 | .00 | .00 | .00 | .00 |
| 023 | .16 | .61 | .00 | .00 | .00 | 50.53 | .00 |
| 024 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |
| 025 | .67 | .61 | 1.45 | .00 | 5.71 | .00 | .00 |

Figure 1d

FUEL INVENTORY RECORD
DOWNED WOODY MATERIAL

PROJECT NAME: EMILY UNIT NO: 0001 ACRES: 40
COMPARTMENT: RESIDUES COMP NO: 2107 CELL NO: 2R07
DATE OF SURVEY: 10-16-78 SURVEYED BY: KIMBERLIN

FUEL SPECIES: 17 70 0 0 0 ROTTEN
AGE OF SLASH: NATURAL NEEDLES RETAINED = 0 %

---------- UNIT SUMMARY ----------

FINE FUEL COMPLEX

| SIZE CLASS | % ERROR | LBS/SQ FT | CU FT/AC | TONS/ACRE |
|---|---|---|---|---|
| NEEDLES | .00 | .00 | .00 | .00 |
| 0.00 - 0.25 | 13.72 | .03 | 42.30 | .63 |
| 0.26 - 1.00 | 18.42 | .07 | 105.87 | 1.59 |
| 1.01 - 3.00 | 15.75 | .14 | 252.18 | 3.15 |
| TOTAL FINE FUEL | 12.40 | .25 | 400.35 | 5.37 |

LARGE FUEL COMPLEX

| SIZE CLASS | % ERROR | LBS/SQ FT | CU FT/AC | TONS/ACRE |
|---|---|---|---|---|
| 3.1 - 6.0 | 43.20 | .06 | 97.24 | 1.35 |
| 6.1 - 10.0 | 32.08 | .17 | 346.81 | 3.70 |
| 10.1 - 20.0 | 37.73 | .47 | 947.61 | 10.26 |
| 20.1 + | .00 | .00 | .00 | .00 |
| TOTAL LARGE FUEL | 26.21 | .70 | 1391.66 | 15.31 |
| TOTAL FUEL COMPLEX | 20.59 | .95 | 1792.01 | 20.68 |

FUEL COMPLEX PARAMETERS

AVERAGE FUEL BED DEPTH .27 FEET PERCENT GROUND COVER 80 %
AVERAGE DUFF DEPTH 1.06 INCHES PERCENT GROUND COVER 86 %
COEFFICIENT OF VARIATION (FINE FUEL ONLY) 62.00 %

THE RECOMMENDED VALUE FOR PARTICAL DENSITY IS 32 LBS/CUFT
TOTAL MINERAL CONTENT IS 5.5% - EFFECTIVE MINERAL IS 1%
HEAT CONTENT IS 8000 BTU/LB OF FUEL (NFDRS 1978)
THESE VALUES ARE USED IN FUEL APPRAISAL

Figure 1e

FUEL INVENTORY RECORD
DOWNED WOODY MATERIAL

PROJECT NAME: EMILY  COMP NO: 2107  CELL NO: 2P07

SPECIES DELINEATION

TONS/ACRE ----

| SPECIES | 3.1 - 6.0 | 6.1 -10.0 | 10.1 -20.0 | 20.1 + | TOTAL |
|---|---|---|---|---|---|
| GRAN FIR | .30 | 2.42 | 7.33 | .00 | 10.06 |
| WT LARCH | .90 | .00 | .00 | .00 | .90 |
| - - - - | .00 | .00 | .00 | .00 | .00 |
| - - - - | .00 | .00 | .00 | .00 | .00 |
| - - - - | .00 | .00 | .00 | .00 | .00 |
| ROTTEN | .15 | 1.28 | 2.92 | .00 | 4.35 |
| TOTAL | 1.35 | 3.70 | 10.26 | .00 | 15.31 |

CUBIC FEET/ACRE ----

| SPECIES | 3.1 - 6.0 | 6.1 -10.0 | 10.1 -20.0 | 20.1 - | TOTAL |
|---|---|---|---|---|---|
| GRAN FIR | 25.93 | 209.88 | 635.31 | .00 | 871.12 |
| WT LARCH | 55.35 | .00 | .00 | .00 | 55.35 |
| - - - - | .00 | .00 | .00 | .00 | .00 |
| - - - - | .00 | .00 | .00 | .00 | .00 |
| - - - - | .00 | .00 | .00 | .00 | .00 |
| ROTTEN | 15.97 | 136.93 | 312.30 | .00 | 465.19 |
| TOTAL | 97.24 | 346.81 | 947.61 | .00 | 1391.66 |

POUNDS/SQ FT ----

| SPECIES | 3.1 - 6.0 | 6.1 -10.0 | 10.1 -20.0 | 20.1 - | TOTAL |
|---|---|---|---|---|---|
| GRAN FIR | .01 | .11 | .34 | .00 | .46 |
| WT LARCH | .04 | .00 | .00 | .00 | .04 |
| - - - - | .00 | .00 | .00 | .00 | .00 |
| - - - - | .00 | .00 | .00 | .00 | .00 |
| - - - - | .00 | .00 | .00 | .00 | .00 |
| ROTTEN | .01 | .06 | .13 | .00 | .20 |
| TOTAL | .06 | .17 | .47 | .00 | .70 |

```
>@DELETE EMILY.
FURPUR 27R3 E32 SL73P1 04/04/79 10:23:08
@FREE,D     PNW*EMILY(1)
CSFs STATUS 600000000000
>@@
@FIN
```

Figure 1f

SAMPLING ERROR

The computer printout gives the percent error as a measure of the variability of the data and accuracy of the prediction. Percent errors of less than 20% are adequate for assessing most fuel problems. Percent errors greater than this usually indicate that more samples need to be taken. The following graph from Brown (1974) indicates the relationship between the number of sample points (transects) and the percent error.

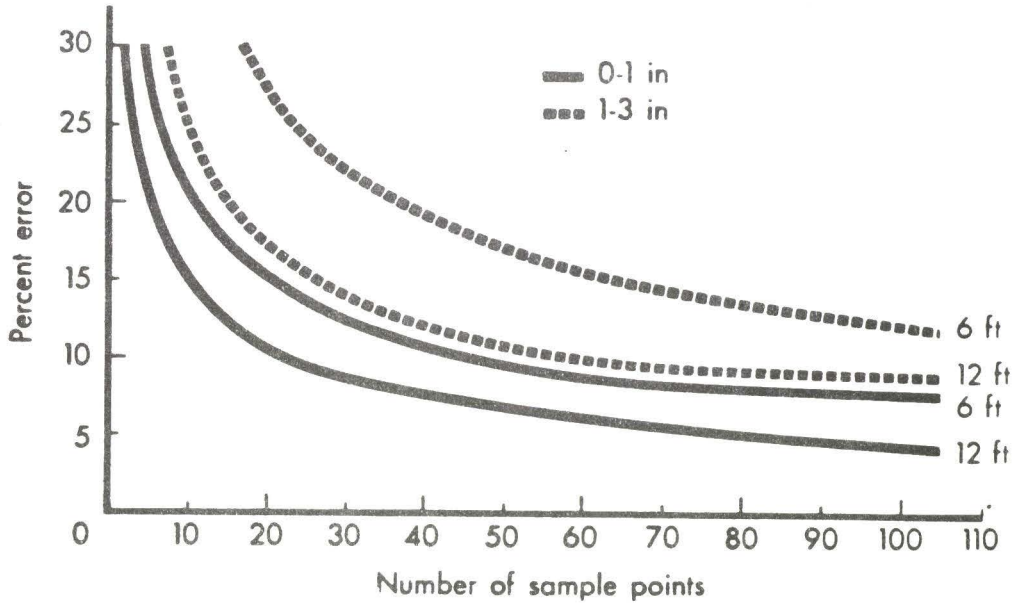



Figure 1g--Percent errors for number of particle intersections along 6- and 12-foot-length sampling planes related to number of sample points for quantities of light slash and nonslash. Percent error is 100 times the standard error of the estimate divided by the mean estimate. (Brown 1974)

What is the percent error and how is it calculated? If fuels are sampled by Brown's (1974) method, each transect yields an estimate of the fuel loading by size class for the unit. Suppose 25 transects are taken randomly distributed throughout the unit. These 25 transects yield 25 estimates of the fuel loading, the average of the estimates being the fuel loading for the unit. The average is also called the mean.

Before we can calculate the percent error, we need to find the standard deviation of our 25 estimates. The standard deviation is nothing more than the weighted average deviation of our 25 estimates of the fuel loading from the mean fuel loading. It is calculated by the following formula:

$$S.D = \sqrt{\frac{\sum (Y_i - \bar{Y})^2}{n-1}} = \sqrt{\frac{\sum (Y_i 2) - n\bar{Y}^2}{n-1}}$$

Where: $\sum$ means "the sum of"
$Y_i$ is a symbol for the samples. i=1, 2, 3,...25
$\bar{Y}$ is our average fuel loading
n is the number of transects we took (25).

Now, don't get excited. The formula looks worse than it really is. Many hand-held calculators will do this calculation for you automatically as they have statistics keys on them. The down woody computer program of FCCC (see figure 1e) does this automatically.

We have now computed the mean and standard deviation from the 25 estimates of the fuel loading. Suppose you were to go out to the same unit for the next 7 days and inventory the fuels the same way. Each day you took 25 transects, returned to the office and computed the mean to determine "that day's" estimate of the fuel loading. When you were done, you would have 8 good estimates of the fuel loading on the unit, but they would differ. Why? Because we really don't know the fuel loading. The only way to find that would be to physically weigh the fuel; but that still would only be as accurate as the scales used! To determine a better estimate of the fuel loading, let's take an average of the 8 fuel loadings. These 8 estimates will differ from this average much less than any of the 25 estimates taken on any given day from the mean of those 25 estimates. We also could calculate a standard deviation for these 8 estimates. This standard deviation has a special name; it is called the standard error of the estimate, or simply the standard error. Statisticians have proved for us that we can estimate this standard error from just our 25 transects we took the first day we sampled. It is simply the standard deviation for our 25 estimates divided by the square root of the number of transects we took (25).

$$\text{Standard Error} = \frac{\text{Standard deviation}}{\sqrt{n}} \qquad n=25$$

Now, here's what we have been looking for, the percent error. The percent error is the standard error divided by the mean of our 25 estimates times 100.

For example, refer to page 13. This printout gives the fuel loading estimate of each size class for each transect. Let's consider only the 1-3" size class. On plot 1, the 1-3" fuel loading is estimated at 7.34 tons per acre and on plot 25 at 1.45 tons per acre. The average of these 25 estimates is 3.15 tons per acre. The standard deviation is 2.48 tons per acre, the standard error is .496 tons per acre, and the percent error is 15.75. The calculations are as follows:

$$\text{Mean} = \frac{78.69}{25} = 3.15$$

$$\text{Standard Deviation} = \sqrt{\frac{\Sigma(Y_i-3.15)^2}{24}} = 2.48$$

$$\text{Standard Error} = \frac{2.48}{\sqrt{25}} = .496$$

$$\text{Percent Error} = \frac{.496}{3.15} \times 100 = 15.75$$

What use is the percent error? Besides being a measure of the variability of your data, it indicates that 68% of the time, the <u>true</u> fuel loading will be between these two values:

$$\text{Mean} + (\text{Mean})\left(\frac{\%\ \text{error}}{100}\right) \qquad \text{and} \qquad \text{Mean} - (\text{Mean})\left(\frac{\%\ \text{error}}{100}\right)$$

For example, 3.15 x .1575 = .5 and 3.15 + .5 = 3.65, 3.15 - .5 = 2.65. Hence, we have a 68% chance that the true 1-3" size class fuel loading is between 2.65 and 3.65 tons per acre. Also, 95% of the time, the <u>true</u> fuel loading will be between the mean plus and minus 2 times the percent error. Therefore, we have a 95% chance the <u>true</u> 1-3" size class fuel loading is between 2.15 and 4.15.

# SECTION II

# OBTAINING DEBRIS PREDICTIONS -DEBMOD6

## II. OBTAINING DEBRIS PREDICTIONS--DEBMOD6

This section of the Users' Guide describes how to use the computer program DEBMOD6 for predicting weight of activity debris. To make the debris estimate, the prediction program (DEBMOD6) uses data from the Region 6 Stand Examination (Forms R6-2410-312 and R6-2410-313). The program estimates debris weight for each inventoried tree, and then sums their weights by species on a per-acre basis. For those Ranger Districts currently doing stand examinations on proposed precommercial thinning or harvesting areas, no additional field work is required except, perhaps, a fuel inventory of existing conditions. However, to obtain a reliable debris prediction for these activity areas there should be no less than 15 stand examination plots taken.

DEBMOD6 estimates debris from foliage, branches, unmerchantable tips, cull trees, and merchantable tree defect (see Figure 2a). DEBMOD6 was modified from DEBMOD which was originally assembled at the Northern Forest Fire Laboratory, Missoula, Montana. Several sources, outlined in Appendix II, were used to modify the relationships for estimating potential debris to reflect conditions found in Region 6.

DEBMOD6 predicts debris from logging or precommercial thinning activity for both conifers and hardwoods. Prediction equations have been developed for ten conifer and five hardwood species. For those species in which prediction equations have not been developed, equations from species with similar branching characteristics are used to make their predictions, however, the name of the species inventoried in the stand examination is printed on the output data from DEBMOD6 (see table 2a).

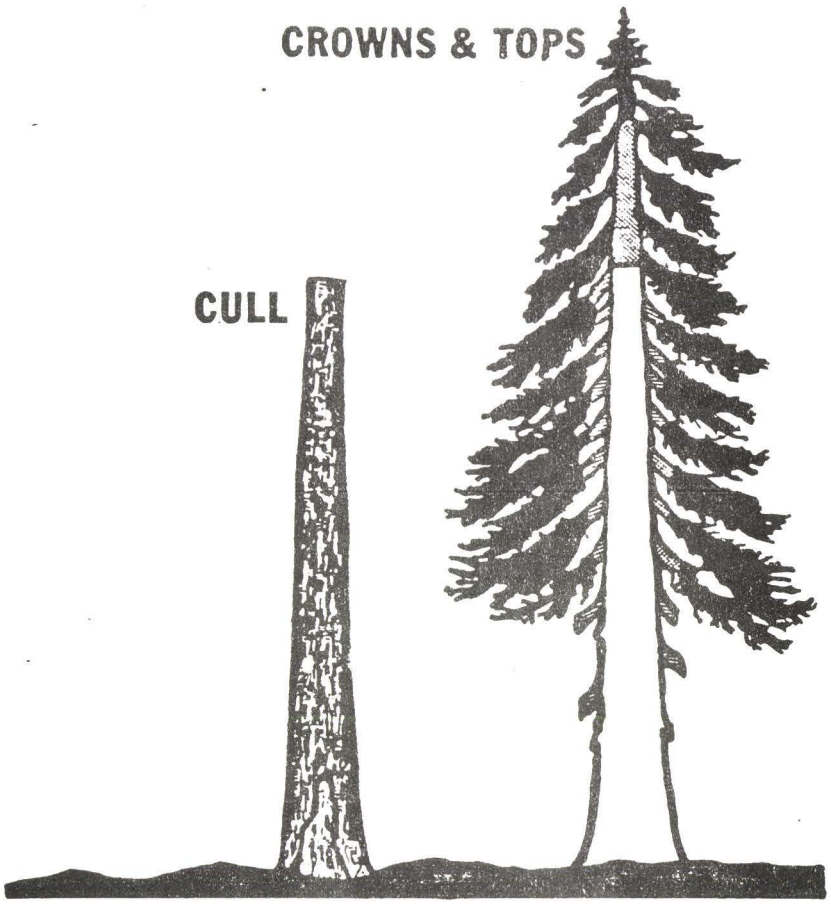
Table 2a.--Species that are included in the DEBMOD6 Program.

| Species in which prediction equations have been developed | Species in which prediction equations have not been developed. Their weight is predicted using the species in the first column |
|---|---|
| | CONIFERS |
| Douglas-fir | Shasta red, Pacific silver, and noble fir |
| Engelmann spruce | Sitka spruce |
| Grand fir | White fir |
| lodgepole pine | Knobcone pine, Whitebark pine |
| Ponderosa pine | Jeffery pine |
| Subalpine fir | |
| Western hemlock | Mountain hemlock |
| Western larch | subalpine larch |
| Western redcedar | incense-cedar and Port-Orford cedar |
| Western white pine | Sugar pine |
| | HARDWOODS |
| Bigleaf maple | Oregon white oak |
| Chinkapin | |
| Pacific madrone | |
| Red alder | All alders, Oregon ash, Black cottonwood, and Quaking aspen |
| Tanoak | California black oak, live oak, and white oak |

For example: if Pacific silver fir is inventoried, Douglas-fir weight equations will be used to estimate the weight of the debris, but debris weights will be printed out under a heading of Pacific silver fir on DEBMOD6 printout.

## USES OF DEBRIS PREDICTION

Debris prediction gives fire managers and resource managers a better way to discuss debris--and it allows them to do so before it is created. Fire managers can deal more effectively with resource managers regarding fuel management needs connected with planned forestry operations that involve cutting trees. The size and amount of debris likely to result from various management options can be stated in terms of probable quantities. More definite debris disposal plans and contracts can be written, and more precise production rates and costs can be computed. Thus, more objective decisions about debris are possible.




DEBRIS IS GENERATED FROM DIFFFRENT PARTS OF A TREE

Cull and defect are determined by multiplying bole volume by percent defect. The defect percentages are estimated by the stand examination.

The <3-inch class includes all foliage live and dead branchwood <3-inch diameter, and the tip portion of the bole less than 3 inches.

The 3-inch and larger class includes all live and dead branchwood and unmerchantable tips 3 inches and larger.

Figure 2a

## ACQUIRING THE DEBRIS PRINTOUT

To obtain a prediction of debris for a given stand, a stand examination must have been completed, processed, and stored at Fort Collins Computer Center (FCCC). The district Silviculturist or Timber Management Assistant should be consulted to verify the existence of the stand examination data at FCCC. The one requirement necessary for the debris prediction is the Card Type II data must be filled out on the Stand Examination Cover Card I (R6-2410-312) (see figure 2b). In the Card Type II Data section, all three parts must be filled in for the stand examination to successfully complete Region 6 editing. The DEBMOD6 program uses the data in part 1 (see figure 2b) if a Girard top is used and data from part 2 if a Girard top is not used. For precommercial thinning, enter a number in part 2 which is at least as large as the diameter of the largest stem to be cut. The coding in part 3 will a 1 for 16 foot logs or a 2 for 32 foot logs. DEBMOD6 does not use part 3 for any of its calculation. If Card Type II Data section is not filled out, DEBMOD6 will not process the stand examination data.

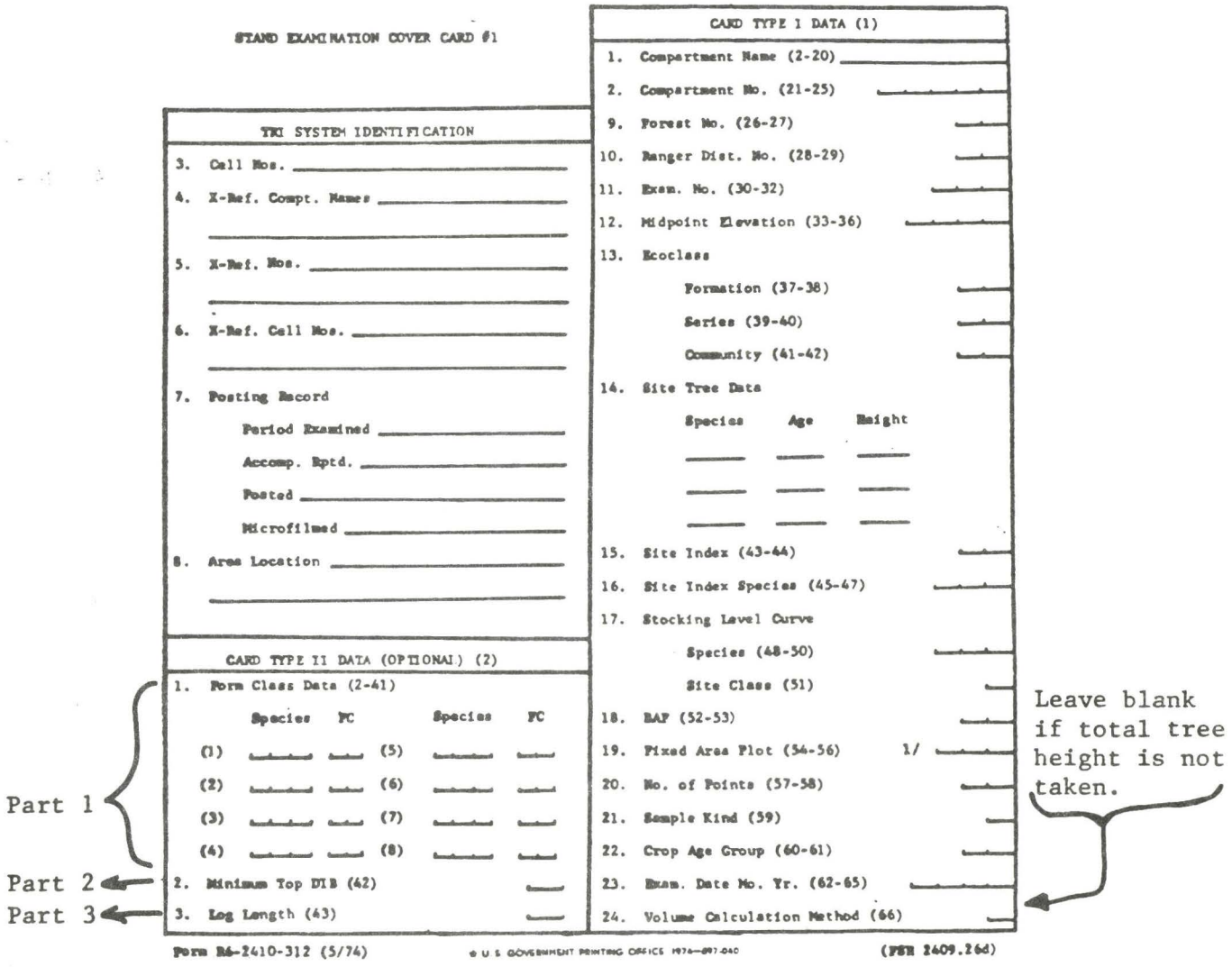



Figure 2b

After the user has verified that 1) a stand exam exists at FCCC, 2) the examination has passed the Region 6 stand examination edit, and 3) that Card Type II has been filled out, it is possible to access FCCC with a remote terminal and obtain a DEBMOD6 printout. When processing the stand examination data through DEBMOD6 it is possible to process many exams very easily in one setting. Although, the user needs to know the following items before a successful run can be completed.

1) Forest name
2) District name
3) Year of the stand examination data
4) Stand examination number(s)
5) An acceptable FCCC 12 digit account number
6) Site ID of a wide carriage computer terminal or printer

Note: If more than one exam is to be processed at the same time, then all must be from the same calendar year.

An actual runstream that accesses and runs DEBMOD6 is as follows:

```
◆UNIVAC 1100 OPERATING SYSTEM  LEV. SA-36R1-8A  (RSI)◆
>@RUN RD6JAK,  XXXXXXXXXXX ,PNW
DATE: 070281  TIME: 115722
WEEKLY ACTIVITY LETTER - NEWS,81-00025
WEEKEND/HOLIDAY SCHEDULE - OPERATIONS,81-00034 (@INFO)WEDNESDAY 12:56
>@XQT STD6◆STD6.DEBMOD6

R6 STAND EXAM SYSTEM - DEB MOD FRONT END   AFV2-380
RUN DATE 07/02/81                    PST 10:57:54


ENTER YOUR FOREST NAME, PLEASE...

>MT. HOOD

ENTER YOUR DISTRICT NAME, PLEASE...

>CLACKAMAS

ENTER THE 2-DIGIT CALENDAR YEAR OF YOUR DATA, PLEASE...

>80

ENTER 1-DIGIT CONTROL VALUE (1 OR 9)...
1-FOLIAGE WEIGHT IS INCLUDED
9-FOLIAGE WEIGHT IS NOT INCLUDED

>1

   BEGIN EXAM NUMBER INPUT CYCLE...
   TO STOP INPUT CYCLE AND START RUN...
   ENTER A ZERO FOR THE EXAM NUMBER...


   ENTER THE DESIRED EXAM NUMBER...
>240

  ENTER ACCOUNT NUMBER FOR RUNNING DEBMOD REPORT...
>: XXXXXXXXXXX
```

All items underlined must be typed by user.

Make sure all 12 alpha-numeric digits are entered.

```
ACCOUNT YOU WISH TO CHARGE IS #XXXXXXXXXXXX
  IS THIS CORRECT? (Y OR N)

>Y

   PLEASE ENTER A SITE ID FOR DEBMOD OUTPUT...

>FCR720
    SITE ID IS FCR720, CORRECT? (Y OR N)

>Y

    ENTER THE NUMBER OF COPIES DESIRED (1 TO 9).

>1

    ****************************************
    OUTPUT MESSAGE FOR SENDING DEBMOD REPORT
    ****************************************

    ENTER A MESSAGE LINE OR "END"...

>SEND TO : KEN SNELL PNW PORTLAND OR.
MESSAGE IS:                SEND TO : KEN SNELL PNW PORTLAND OR.


    ENTER A MESSAGE LINE OR "END"...

>END
    EXAM  240 PROCESSED


   ENTER THE DESIRED EXAM NUMBER...
>238
    EXAM  238 PROCESSED


   ENTER THE DESIRED EXAM NUMBER...
>239
    EXAM  239 PROCESSED


   ENTER THE DESIRED EXAM NUMBER...
>0
** @START STD6*DEBMOD115927. .      ***

REQUEST HAS BEEN PROCESSED...

END OF DEBMOD FRONT END...



>@FIN
```

Enter your own site ID or the ID of a high speed printer where you want your output to be printed. The output devise must be able to print 132 characters in width. Use @@TTY W,132 to change width on low speed terminals.

Note that many exams from the same year may be processed during one session. After putting in all exam numbers, type a 0 to start processing.

At this point, FCCC will process your DEMBOD6 requests on a low priority basis. Therefore, it may be a day before your output is available. If you have designated your output to be printed on a high speed printer, it will be printed automatically when processed. However, be sure to have a complete message on your output so computer personnel will know where to send your output. If you have designated your low speed terminal as the output site, you will need to check periodically to see if your output is available for printing.

Following an @ FIN and the display of cost data, the computer will print *TERMINAL INACTIVE* OUTPUT FILE AVAILABLE, if output is ready to be printed. To obtain this output, type in @@ TTY W, 132 and then a carriage return and then a @@ SEND and another carriage return. At this point the output should start coming back. However, upon initial sign on to the computer, the entry of these two commands at the first prompt (>) will result in the printing of output if available. Note, it is not necessary to enter on @ RUN statement to get output as you have already paid for the run.

An example output from DEBMOD6 is shown in figure 2c.

The DEBMOD6 printout shows, by species and d.b.h. classes, oven-dry weights in tons per acre of residue that could be created if all trees were cut. Green weights, such as found immediately after cutting, are approximately twice the oven-dry weights.

The debris prediction from DEBMOD6 assumes all stems will be cut. To determine the amount of debris created by partial cutting, the total potential debris must be adjusted to include only trees cut or broken. This can be done by either adding up debris for those trees to be felled or by subtracting debris from the total for leave trees.

Debris is created primarily by cutting. However, trampling of small trees and breakage of large felled trees also produce debris. To predict debris for a partial cut, the contribution from each of these sources must be estimated. The following explanation of cutting, trampling, and breakage will help in making these estimates:

Cutting--Two sources of debris result from cutting. First, there is the foliage, limbwood, and unmerchantable tops of cut trees. This debris is printed under the headings <3, and 3, >3 (see Figure 2c). Second, there is cull material (shown in Figure 2c under the cull heading). The amount of cull debris on the printout is estimated by multiplying each tree's bole volume by its percent defect and then summing this defect for all trees to a per acre basis. This is done automatically within DEBMOD6. This will usually overestimate the cull since some defect will be removed and transported to a mill. Local experience will have to be used to reduce the cull estimate according to how much defect might be hauled away.

Trampling--This source of debris is created by logging equipment pushing over small trees. This debris can be estimated from the printout for trees with d.b.h. equal to or less than the unmerchantable top diameter, because their total weight (inclusive of entire bole) appears under <3 and 3, >3 columns. To calculate debris from trampling, estimate the proportion of trees that might be trampled for each d.b.h. class of the trees described above and multiply the proportion times the potential debris. In some stands, trampling can be neglected, while in other stands, it may create a significant amount of debris and should be estimated.

Breakage--Debris is created when trees that are apparently sound break up when felled. Breakage is difficult to estimate accurately. For Region 6 east of the Cascade Mountains, it is probably a small percentage of merchantable tree volumes for most sales. However, on the west-side of the Cascades, in old-growth, the breakage is greater. To calculate breakage, use local knowledge or experience available and estimate a percent of the gross merchantable volume that could be left as breakage. Several experienced timber people in Region 6 have estimated that breakage typically ranges from two to eight percent for east of the Cascades and, for west-side old-growth, it is typically fifteen percent. For further information on estimating defect west of Cascades, see Dilworth (1972). Using this percent, calculate the cubic foot volume of breakage and multiply by 25 pounds per cubic-foot (average of wood densities used in DEBMOD6) to find weight in pounds. Divide by 2,000 to get tons per acre.

## DEBRIS PREDICTION DEFINITIONS

Terms identifying printout headings are:

CROWNS, TOPS

<3 --This size class includes all foliage, branchwood, small trees, boles less than 3 inches, and unmerchantable tip pieces less than 3 inches in diameter. However, adjustments are made for tree histories 2 and 3. (See table 2b)

3, >3 --This size class includes all branches, small tree boles, and unmerchantable tip pieces 3 inches and greater in diameter.

CULL --Includes estimated defect from all trees. (See table 2c). The estimate of defect apples only to the merchantable part of the stem.

D.B.H. GROUP--Diameter at breast height of trees inventoried during stand examination.

## OTHER DEBRIS PREDICTION METHODS

The debris prediction program (DEBMOD6), described in this guide, is the most accurate method for predicting slash fuels because crown and bole weights are estimated on a tree-by-tree basis. It should be used when possible.

Two additional handbooks are available for use in predicting debris. They may be used when a stand exam has not been made or the field data will not be processed in time to meet information needs. Debris from small salvage sales and cuttings can also be estimated more conveniently using these procedures.

For Region 6 eastside National Forests use:

Brown, James K., J. A. Kendall Snell, and David L. Bunnell. 1977. Handbook for predicting slash weight of western conifers. USDA For. Serv. Gen. Tech. Rep. INT-37, 35 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

For Region 6 westside National Forests use:

Snell, J. A. Kendall and James K. Brown. 1980. Handbook for predicting residue weight of Pacific conifers. USDA For. Ser. Pacific Northwest Forest and Range Exp. Stn. Gen. Tech. Rpt. PNW-103.

The following may be helpful in making independent residue weight estimates for hardwoods:

Snell, J. A. Kendall. 1981. Equations and Tables for estimating weights for Pacific madrone and Tanoak. USDA For. Serv. Pacific Northwest Forest Range & Exp. Stn. General Tech. Report PNW-126, 25 p.

## ACCURACY OF DEBRIS PREDICTION

Weights are expressed on the Debris Prediction Printout to two decimal places. Total weights should be rounded to the nearest 1 ton, or to the nearest 5 tons if there is a lot of cull weight. Based on studies by the Northern Forest Fire Laboratory, standard errors often attained with the stand exam inventory and those associated with the debris prediction functions suggest that debris estimates should be within 20 percent of the true mean most of the time. Estimates can deviate from the true mean by as much as 50 percent.

## CONTRIBUTION OF DEBRIS FOR TREE HISTORY CODES

Table 2b

| Tree 1/ History Code | Definition of Trees | Percent of tree component that is actually considered available for debris | | | | |
|---|---|---|---|---|---|---|
| | | Foliage | Branches | Tips | Bole | Bark |
| 1, 4, & 5 | 1 = Live tree<br>4 = Non-commercial<br>5 = Trees already marked for harvesting | 100 | 100 | 100 | 100 | 100 |
| 2 | Salvable dead | 40 | 40 | 100 | 100 | 100 |
| 3 | Unmerchantable dead | 0 | 40 | 0 | 100 | 0 |

1/ For tree history code interpretations see Region 6 stand examination procedures.

## ACTUAL DEFECT PERCENTAGES USED IN DEBMOD6 AS INDICATED BY STAND EXAMINATION DEFECT CODES

Table 2c

| Stand Exam Defect codes | Range in percent defect | Actual percent used in DEBMOD |
|---|---|---|
| 0 | No defect | 0 |
| 1 | 1-10 | 5.5 |
| 2 | 11-20 | 15.5 |
| 3 | 21-75 | 48.0 |
| 8 (Sound cull) | 76-100 | 88.0 |
| 9 (Rotten cull) | 76-100 | 100.0 |

## SUMMARIZING DEBRIS BY CUTTING PRESCRIPTION

The following example shows how to summarize debris from a debris prediction printout to reflect a given cutting prescription.

Prerequisite to summarizing the debris is a formal cutting prescription (whether it be for harvesting or precommercial thinning). This should be available from the District silviculturist. The prescription must include trees per acre by species and d.b.h. class of those trees being cut or left. The example below is for a hypothetical shelterwood cut of Douglas-fir, western red cedar, and grand fir and highlights steps necessary to summarize potential debris. For many cutting prescriptions, such as clear-cut and thinning, the debris summaries will be simpler than shown in this example. For this example, we will assume that all cull material remains on site. However, in some areas, a portion of the cull will be removed, which means the cull summation must be reduced. Local experience must be used to make this reduction. Debris is summarized for cutting, trampling, and breakage as follows:

### INFORMATION OBTAINED FROM CUTTING PRESCRIPTION

The following information was obtained from the District Silviculturist:

I. Type of cut -- shelterwood

   A. Douglas-fir--80 percent of all Douglas-fir 17 inches d.b.h. and over will be marked for cutting.

   B. Grand fir--

      1. One hundred percent of all grand fir 9 inches d.b.h. and over will be marked for cutting.

      2. It is estimated that 15 percent of all grand fir less than 4 inches d.b.h. will be pushed over due to logging.

   C. Western redcedar--100 percent of western redcedar will be cut.

In addition, the following information was obtained:

- Estimated percent breakage of merchantable volume is 15 percent.
- The gross volumes per acre of trees being harvested are:

  Douglas-fir - - - 18,000 ft

  Grand fir - - - - 400 ft

  Western redcedar - 1,600 ft

- Merchantable top diameter is 6 inches.

EXAMPLE OF SUMMARIZING POTENTIAL DEBRIS

Note on the debris prediction printout (Figure 2c) that the estimated weights are given by species and d.b.h. classes, and totaled by species for the stand. Also, the weights shown on the printout are approximations of the total standing tree debris. In other words, if the stand were to be clearcut, the total weights given for the stand (lower righthand corner, Figure 2c) are estimates of the debris created. Since this example is a shelterwood cut, not all the potental debris will be created. Consequently, the weights in Figure 2c must be adjusted by the percentages indicated in the prescription and entered on the Debris Potential Summary Form (Figure 2d).

Filling out the Debris Potential Summary Form is an optional step. Once the user is familiar with the debris prediction and hazard appraisal procedures, the user may wish to skip this step and summarize potential debris directly on the Slash Hazard Data Form (Figure 3a). However, caution must be used not to enter data incorrectly on the Slash Hazard Data Form, because its format does not match the debris prediction printout's format (Figure 2c).

I. Cutting

A. Douglas-fir-80 percent of all Douglas-fir 17 inches d.b.h. and over will be cut. Therefore, take 80 percent of the <3, 3, >3 inch, and cull weights from the debris prediction printout (Figure 2c) that are shown under Douglas-fir for trees equal to or greater than 17 inches dbh. Record the results on the Debris Potential Summary Form (Figure 2d).

Example: For Douglas-fir dbh 17-18.9 inches

<3 inch material, .21 x .80 = .17
3,>3 inch material, .02 x .80 = .02
cull material, .10 x .80 = .08

Continue to do this for the rest of the Douglas-fir greater than 17-18.9 inches dbh, and record the results on Figure 2d.

ENTER ALL VALUES ON THE DEBRIS POTENTIAL SUMMARY FORM AS THREE CHARACTERS.

For example: 123,12.,012,1.2,.12,.01
Note: 12. and 012 are equivalent; so are 1.0 and 001.

II. Trampling

According to the cutting prescription, 15 percent of the Grand fir under 4 inches dbh will be trampled. This weight can be estimated by taking 15 percent of the weights of Grand fir trees less than 4 inches dbh.

Example: For Grand fir, 1 inch dbh

| | | | |
|---|---|---|---|
| <3 inch material | .06 | x .15 | = .01 |
| 3,>3 inch material | 0 | x .15 | = 0.0 |
| cull material | 0 | x .15 | = 0.0 |

Continue to do this for the rest of the 2 and 3 inch dbh Grand fir, and record the results on Figure 2d.

III. Breakage

Obtain an estimate of the merchantable volume (per acre) for each species being harvested. Make sure that this volume is for only those trees being cut. This volume is used to calculate the breakage volume which is changed to weight by multiplying it by wood density. An average of 25 lbs/cu.ft. for Western conifers is commonly used, and will be used in this example. If the user wishes to use the density for each species, refer to Appendix III for species densities.

For this example the total merchantable volume per acre was 18000+400+1,600 = 20,000 cu.ft.

It was estimated that 15 percent of this volume would be lost to breakage and left on site. To estimate the tonnage of this breakage multiply the 20,000 cu.ft. by .15 to obtain the actual breakage volume and then multiply by 25 lb/cu.ft. and divide by 2000 to change volume to tons per acre.

20,000 x .15 x 25 ÷ 2000 = 37.5 (round to 38. tons per acre)

This breakage is recorded on Figure 2d in the upper right hand corner.

The procedures described above can be used to summarize debris for any cutting situation. For example, debris created from precommercial thinnings and overstory removals is calculated in the same way as in the shelterwood cut example. Since the total bole weight is included in the debris prediction for those trees with dbh equal to or less than the merchantable top diameter, a large top diameter should be specified for precommercial thinning areas. The merchantable top specification should be no smaller than the largest tree expected to be cut in the precommercial thinning. Clearcut treatments simply involve transposing the DEBMOD6 printout (Figure 2c) to the Debris Potential Summary Form (Figure 2d). A blank copy of the Debris Potential Summary Form is included in the back of this guide so copies can be made by the user.

Once the Debris Potential Summary has been completed, it is an easy task to transfer the data to the Slash Hazard Data Form (Figure 3a), and obtain a fire assessment from the program HAZARD. The procedures needed to access HAZARD and how to interpret its results are discussed in Section III.

DEBRIS POTENTIAL IN TONS PER ACRE FOR.. 12/06/78

REGION 6 FOREST 11 DISTRICT 4 EXAM NO. 565 OUTPUT OPTION 1 MERCHANTABLE TOP DIAMETER LIMIT 6 INCHES

| SPECIES--> | DOUGLAS-FIR | | | GRAND FIR | | | WESTERN REDCEDAR | | | PONDEROSA PINE | | | LODGEPOLE PINE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CROWNS,TOPS | | | CROWNS,TOPS | | | CROWNS, TOPS | | | CROWNS,TOPS | | | CROWNS,TOPS | | |
| DEBRIS---> DBH GROUP | <3 | 3,>3 | +CULLS | <3 | 3,>3 | +CULLS | <3 | 3,>3 | +CULLS | <3 | 3,>3 | +CULLS | <3 | 3,>3 | +CULLS |
| 1.0- 1.9 | 0 | 0 | 0 | .06 | .00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2.0- 2.9 | 0 | 0 | 0 | .49 | .02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3.0- 3.9 | 0 | 0 | 0 | .41 | .12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4.0- 4.9 | 0 | 0 | 0 | .32 | .14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5.0- 5.9 | 0 | 0 | 0 | .46 | .27 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6.0- 6.9 | 0 | 0 | 0 | 1.05 | 1.01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7.0- 7.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8.0- 8.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9.0-10.9 | 0 | 0 | 0 | 1.27 | .38 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11.0-12.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13.0-14.9 | .23 | .05 | .05 | .69 | .10 | .82 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15.0-16.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17.0-18.9 | .21 | .02 | .10 | 1.50 | .15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19.0-24.9 | .20 | .02 | 0 | .86 | .07 | 0 | .32 | .01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25.0-29.9 | .84 | .07 | .07 | .49 | .02 | .06 | .05 | .01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30.0-39.9 | 1.94 | .16 | 0 | .24 | .01 | 0 | .19 | .01 | 1.05 | 0 | 0 | 0 | 0 | 0 | 0 |
| 40.0-49.9 | 7.59 | .63 | 1.31 | 0 | 0 | 0 | .74 | .02 | 3.49 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50.0-59.9 | 5.80 | .54 | 2.89 | 0 | 0 | 0 | .31 | .00 | .65 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60.0+ | 1.95 | .21 | 2.80 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 18.74 | 1.70 | 7.22 | 7.83 | 2.30 | .88 | 1.62 | .04 | 5.19 | 0 | 0 | 0 | 0 | 0 | 0 |

| SPECIES--> | WESTERN LARCH | | | SUBALPINE FIR | | | WESTERN WHITE PINE | | | OTHER SPECIES | | | ALL SPECIES | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CROWNS,TOPS | | | CROWNS,TOPS | | | CROWNS,TOPS | | | CROWNS,TOPS | | | CROWNS,TOPS | | |
| DEBRIS---> DBH GROUP | <3 | 3,>3 | +CULLS | <3 | 3,>3 | +CULLS | <3 | 3,>3 | +CULLS | <3 | 3,>3 | +CULLS | <3 | 3,>3 | +CULLS |
| 1.0- 1.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .06 | .00 | 0 |
| 2.0- 2.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .49 | .02 | 0 |
| 3.0- 3.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .41 | .12 | 0 |
| 4.0- 4.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .32 | .14 | 0 |
| 5.0- 5.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .46 | .27 | 0 |
| 6.0- 6.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.05 | 1.01 | 0 |
| 7.0- 7.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8.0- 8.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9.0-10.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.27 | .38 | 0 |
| 11.0-12.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13.0-14.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .91 | .16 | .86 |
| 15.0-16.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17.0-18.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.71 | .17 | .10 |
| 19.0-24.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.39 | .09 | 0 |
| 25.0-29.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.37 | .10 | .13 |
| 30.0-39.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2.37 | .18 | 1.05 |
| 40.0-49.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8.33 | .65 | 4.80 |
| 50.0-59.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6.10 | .55 | 3.54 |
| 60.0+ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.95 | .21 | 2.80 |
| TOTAL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 28.40 | 4.21 | 13.28 |

Figure 2c

## Debris Potential Summary Form (Tons/Acre)

EXAM. NO. 565 DATE 1/1/79 SUMMARIZED BY SAMPLER

UNIT NAME EXAMPLE COMPARTMENT NAME

| | SPECIES------ | DF | | | GF | | | WRC | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | DEBRIS------ | <3 | 3, >3 | cull | <3 | 3, >3 | cull | <3 | 3, >3 | cull | BREAKAGE |
| | DBH GROUP 1.0 – 2.0 | | | | .01 | | } TRAMPLING TOTAL = .16 | | | | 3.8. |
| | 2.0 – 3.0 | | | | .07 | | | | | | |
| | 3.0 – 4.0 | | | | .06 | .02 | | | | | |
| | 4.0 – 5.0 | | | | | | | | | | |
| | 5.0 – 6.0 | | | | | | | | | | |
| | 6.0 – 7.0 | | | | | | | | | | |
| | 7.0 – 8.0 | | | | | | | | | | |
| | 8.0 – 9.0 | | | | | | | | | | |
| | 9.0 – 11.0 | | | | 1.3 | .38 | | | | | |
| | 11.0 – 13.0 | | | | | | | | | | |
| | 13.0 – 15.0 | | | | .69 | .10 | .82 | | | | |
| | 15.0 – 17.0 | | | | | | | | | | |
| | 17.0 – 19.0 | .17 | .02 | .08 | 1.5 | .15 | | | | | |
| | 19.0 – 25.0 | .16 | .02 | | .86 | .07 | | .32 | .01 | | |
| | 25.0 – 30.0 | .67 | .06 | .06 | .49 | .02 | .06 | .05 | .01 | | |
| | 30.0 – 40.0 | 1.6 | .13 | | .24 | .01 | | .19 | .01 | 1.1 | |
| 30+ | 40.0 – 50.0 | 6.1 | .50 | 1.1 | | | | .74 | .02 | 3.5 | |
| | 50.0 – 60.0 | 4.6 | .43 | 2.3 | | | | .31 | | .65 | |
| | 60+ | 1.6 | .17 | 2.2 | | | | | | | |
| 30+ TOTAL | | 1.4. | 1.2 | 5.6 | .24 | .01 | | 1.2 | .03 | 5.3 | |
| GRAND TOTAL | | 1.5. | 1.3 | 5.7 | 5.2 | .75 | .88 | 1.6 | .05 | 5.3 | |

Figure 2d

# SECTION III -
# HAZARD APPRAISAL

## III. HAZARD APPRAISAL

Hazard appraisal describes the potential behavior of a wildfire burning in the debris predicted using the procedures described in Sections I and II.

A computer program called HAZARD has been developed by Northern Forest Fire Laboratory researchers to predict fire behavior. The program resides at Fort Collins Computer Center (FCCC), where it is available for national use. The procedures for accessing this program are described in this section.

Before the HAZARD program can be executed, the applicable debris information summarized on the Debris Potential Summary Form (Figure 2d) must be transferred to the Slash Hazard Form (Figure 3a).

## USES OF FIRE BEHAVIOR PREDICTIONS

The hazard appraisal describes the potential fire behavior associated with the predicted debris. Moisture content of fuels can be specified; otherwise, severe fuel moisture is assumed (1-hour timelag fuel moisture --5 percent). Fire behavior estimates are given for a range of windspeeds (0 to 20 mph) and for 1, 3, and 5 years after debris is created. The fire behavior estimates include:

1. Head fire spread rate
2. Perimeter growth rate
3. Burned area after 1 hour
4. Head fire flame length
5. Crown scorch height by head fire
6. Intensity at head of fire
7. Heat load of residual fire from burnout of larger fuels and duff
8. Burn time of residual fire.

Values for the above fire behavior elements are given for each specified cutting scheme, skidding method, and utilization standard. Also, the effect of lopping slash to a 2-foot standard depth is given.

"CAUTION"

THE FIRE BEHAVIOR PREDICTIONS GIVEN BY THE HAZARD APPRAISAL TECHNIQUE MAY NOT BE SUITABLE FOR PLANNING PRESCRIBED FIRE, BECAUSE IT PREDICTS ONLY FOR HEAD FIRES AND DOES NOT CONTAIN ESTIMATES OF FUEL CONSUMPTION. DEBRIS ESTIMATES TOGETHER WITH GUIDES SUCH AS NORUM (1977) OR MARTIN AND DELL (1978) SHOULD BE USED FOR PLANNING PRESCRIBED FIRE.)

Hazard appraisal estimates allow the manager to study the effect of forestry practices on potential fire behavior. The manager can make separate computer runs using different combinations of cutting schemes, utilization standards, and skidding methods to answer such questions as:

-What is the effect of changing utilization standards from a 6-inch top to a 9-inch top on potential debris and associated fire behavior?

-What is the effect of changing skidding method from ground lead to skyline on potential debris and associated fire behavior.

-What is the effect of changing number of leave trees per acre from 300 to 500 on potential debris and associated fire behavior?

The answers to these kinds of questions, properly interpreted, can provide an objective basis for improved debris disposal decisions for planned forestry operations. The fact that the decisions can be made before any trees are cut adds to the significance of the technique as a fire and resource management planning tool.

## COMPLETING THE SLASH HAZARD DATA FORM

The Slash Hazard Data Form is reversed in format from the debris prediction printout for convenience in key punching. As a result, the easiest way to handle the data is to transfer the appropriate information from the debris prediction printout (Figure 2c) to the Slash Hazard Form (Figure 3a) via the Debris Potential Summary Form (Figure 2d) which is optional. The Slash Hazard Data Form provides for two types of input: 1) predicted debris (calculated in Section II), and 2) existing downed fuel inventory (calculated in Section I). Consult the back of the Slash Hazard Data Form (Figure 3a) for coding instructions.

Fill out the Slash Hazard Data Form as follows:

PROJECT IDENTIFICATION. -- Use any desired description up to 48 characters.

UTILIZATION STANDARD. -- Record the merchantable top diameter limit to the nearest whole inch or tenth of an inch, such as 6.0. Record 0 or leave blank for precommercial thinning.

METHOD OF SKIDDING -- Check the method of skidding that is most like the method used. Precommercial thinning is denoted by no skidding. Ground lead skidding includes methods such as tractor, jammer, and high lead.

LOP DEBRIS -- If the effect of lopping on fire behavior is desired as output, check yes; otherwise, check no.

MOISTURE PERCENT -- Fuel moisture contents may be specified by the user or left for the HAZARD Program to specify. On the data form, any unspecified (blank or zero) values will be replaced by the prestored moisture contents in the program. Moisture contents should be entered to the nearest whole percent in the 3 blank spaces allotted for each entry. (For example: Nine percent moisture content is entered as 9.0). The quantities that can be specified and their prestored values are:

| FUEL COMPONENT | PRESTORED MOISTURE, PCT | REMARKS |
|---|---|---|
| 1-HR TIMELAG | 5 | Used for grass* (if any), foliage**, and 0-1/4 inch woody fuels. |
| 10-HR TIMELAG | 7 | Used for 1/4-1 inch woody fuels. |
| 100-HR TIMELAG | 9 | Used for 1-3 inch woody fuels. |
| 1000-HR TIMELAG | 12 | Used for 3+ inch woody fuels. |
| DUFF | 20 | Average for L+F layers combined. |

*Only dead grass is to be input to HAZARD. If there is mostly live grass on site, specify Little or None.

**Program HAZARD assumes that slash has cured. It will not handle fresh slash with a high foliage moisture content.

When specifying fuel moisture values to be used in place of the default values, be sure to. . .

1. Specify moisture contents as percent, to nearest whole percent.

2. Blank or zero values entered will be ignored, and prestored values substituted for missing entries.

3. The program computes a weighted average fuel moisture content that is very heavily dependent on the one-hour timelag fuel moisture. This weighted average value is compared to a "limit" value (moisture of extinction) that depends on fuel bed compactness. If the weighted average moisture content exceeds this limit the model predicts no fire spread. You may find such a notice printed out when you run the program using specified (rather than preset) moisture values. This should not be interpreted literally as "No fire will spread here" but rather as "The fine fuel moisture is so high that model predictions are a poor guide to burning conditions." In this case, if slash is the dominant fuel, fire should be expected to spread very slowly or not at all.

4. In fire modeling neither 1000-hr timelag fuel moisture or "duff" moisture affects the prediction of rate of spread. The residual fire, as reflected in burning time and heat load figures, is strongly influenced by these moistures and only weakly affected by the finer-fuel moistures.

5. The word "duff" refers to the combined L and F layers of the forest floor, excluding the H layer. The duff moisture content represents the average moisture content of these two strata.

DEBRIS PREDICTION. -- Transfer debris weights from the debris prediction printout on the optional Debris Potential Summary Form (Figure 2d) to the Slash Hazard Form (Figure 3a). Be sure breakage is recorded in the "BKG" row under the 8 to 9-inch d.b.h. class, which approximates the diameter of broken boles. One data form will handle five species. If more than five species, use a second form. The 11 species of western conifers and their codes that are acceptable to the HAZARD program are listed on the back of the Slash Hazard Form (Figure 3a).

If the user wants to appraise hazard in species other than those listed on the back of the Slash Hazard Form, substitute one of those listed that is most similar to the desired species. Only those codes listed on the back of the form will be accepted by the HAZARD program.

When two or three forms are used, complete the lower part (downed woody fuel, grass, and slope) on only the last form. Record breakage only once--on last form--if more than one form is used. Recording 3, >3 inch material that appears on the debris prediction printout for d.b.h. less than 1 inch (hatched areas) is unnecessary because of the very small amounts involved.

Species of tree is indicated by a two or three letter code. There is space to enter three letters in the column labeled Spp. When a two letter code is used, start in the left most space available, leaving the last space blank.

DOWNED WOODY MATERIAL. -- Loadings of downed woody material prior to cutting should be entered on the form. Be sure loadings are entered as shown in the coding instructions. Loadings of downed woody material can be inventoried and the data processed in one of the three ways already described in Section I. When obtaining data from FCCC computer output, be sure to note that the total large fuel complex includes both sound and rotten material. Use the table identified in Figure 1f to separate the total large fuel complex into its sound and rotten components.

GRASS LOAD. -- This permits the effect of grass and sedge fuels on fire behavior to be considered. Amounts will be light or moderate on average sites; heavy on very grassy sites.

SLOPE PERCENT. -- Enter the average slope to the nearest 10 percent.

Completed Slash Hazard Forms will be sent to the Forest Computer specialist for processing or can be processed on the Ranger District if a computer terminal is available. A sample runstream is included at the end of this section.

# SLASH HAZARD DATA FORM



PROJECT IDENTIFICATION (up to 48 characters) Example for Users' Guide (1-48)

UTIL. STD. 6.0 (1-10) (11-13) * INCH MERCANTABLE TOP (blank for precommercial thinning)

HELICOPTER OR SKYLINE SKIDDING _____ (PUNCH 1-10) GROUND-LEAD SKIDDING X (OMIT CARD) NO SKIDDING _____ (OMIT CARD) (check one)

LOP DEBRIS (1-10) X (PUNCH 1-10) YES _____ (OMIT CARD) NO

MOISTURE % (1-8) STD. X (OMIT CARD) 1 Hr _____ (11-13) 10 Hr _____ (14-16) 100 Hr _____ (17-19) 1000 Hr _____ (20-22) Duff _____ (23-25)

1. ENTER LOADING, TONS/ACRE, BY SPECIES AND D.B.H. CLASS, FROM DEBRIS-PREDICTION RESULTS

| Field | | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | D.B.H. classes in inches | | | | | | | | | | | | | | | | |
| (1-4) SIZE | (6-8) SPP. | (11-13) 0-1 | (14-16) 1-2 | (17-19) 2-3 | (20-22) 3-4 | (23-25) 4-5 | (26-28) 5-6 | (29-31) 6-7 | (32-34) 7-8 | (35-37) 8-9 | (38-40) 9-11 | (41-43) 11-13 | (44-46) 13-15 | (47-49) 15-17 | (50-52) 17-19 | (53-55) 19-25 | (56-58) 25-30 | (59-61) 30+ |
| −3IN | D.F. | | | | | | | | | | | | | | .1.7 | .1.6 | .6.7 | 1.4. |
| 3+ IN | D.F. | | | | | | | | | | | | | | .0.2 | .0.2 | .0.6 | 1..2 |
| CULL | D.F. | | | | | | | | | | | | | | .0.8 | | .0.6 | 5..6 |
| −3IN | G.F. | | .0.1 | .0.7 | .0.6 | | | | | | 1..3 | | .6.9 | | 1..5 | .8.6 | .4.9 | .2.4 |
| 3+ IN | G.F. | | | | .0.2 | | | | | | .3.8 | | .1.0 | | .1.5 | .0.7 | .0.2 | .0.1 |
| CULL | G.F. | | | | | | | | | | | | .8.2 | | | | .0.6 | |
| −3IN | W.R.C. | | | | | | | | | | | | | | | .3.2 | .0.5 | 1..2 |
| 3+ IN | W.R.C. | | | | | | | | | | | | | | | .0.1 | .0.1 | .0.3 |
| CULL | W.R.C. | | | | | | | | | | | | | | | | | 5..3 |
| −3IN | | | | | | | | | | | | | | | | | | |
| 3+ IN | | | | | | | | | | | | | | | | | | |
| CULL | | | | | | | | | | | | | | | | | | |
| −3IN | | | | | | | | | | | | | | | | | | |
| 3+ IN | | | | | | | | | | | | | | | | | | |
| CULL | | | | | | | | | | | | | | | | | | |
| CULL | BKG | | | | | | | | | 3.8. | | | | | | | | |

2. ENTER LOADINGS, TONS/ACRE, BY SIZE CLASS, FROM DOWN-WOODY INVENTORY RESULTS

| Field | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | SOUND | | | | ROTTEN | | | | |
| Size class | 0-.25 | .25-1 | 1-3 | 3-6 | 6-10 | 10-20 | 20+ | 3-6 | 6-10 | 10-20 | 20+ | DUFF |
| DOWN FUELS (1-10) | .6.3 (11-13) | 1..6 (14-16) | 3..2 (17-19) | 1..2 (20-22) | 2..4 (23-25) | 9..3 (26-28) | 0.0.0 (29-31) | .1.5 (32-34) | 1..3 (35-37) | 2..9 (38-40) | 0.0.0 (41-43) | 0.1.5 (44-46) |

For duff loading, multiply duff depth in inches by 14.5 except for ponderosa pine. For PP duff multiply by 10.0 instead.

GRASS LOAD (1-10) _____ (1 IN CC 11) HEAVY _____ (CC 11 BLANK) MODERATE X (OMIT CARD) LITTLE OR NONE (check one)

SLOPE PCT (1-10) 0.0.0 (11-13)

SPECIES CODES FOR SLASH HAZARD APPRAISAL DATA FORM

| COMMON NAME(S) | SCIENTIFIC NAME | SPECIES CODE | ALSO USE FOR |
|---|---|---|---|
| Subalpine fir | *Abies lasiocarpa* | AF | |
| Douglas-fir | *Pseudotsuga menziesii* | DF | |
| Engelmann spruce | *Picea engelmannii* | ES | |
| Grand fir | *Abies grandis* | GF | |
| Lodgepole pine | *Pinus contorta* | LP | |
| Ponderosa pine, Yellow pine, Bull pine | *Pinus ponderosa* | PP | |
| Whitebark pine | *Pinus albicaulus* | WBP | Limber pine |
| Western hemlock | *Tsuga heterophylla* | WH | Mountain hemlock |
| Western larch, Tamarack | *Larix occidentalis* | WL | Alpine larch |
| Western redcedar | *Thuja plicata* | WRC | |
| Western white pine | *Pinus monticola* | WWP | |

ENTER NUMERICAL QUANTITIES AS THREE CHARACTERS. EXAMPLES:

123 12. 012 1.2 001 .12 .01 NOTE: 12. AND 012 ARE EQUIVALENT SO ARE 1.0 AND 001

THREE-CHARACTER FORMAT APPLIES TO ALL ENTRIES, INCLUDING MERCHANTABLE TOP STANDARD, DEBRIS LOADING, DOWN-WOODY FUEL LOADINGS, DUFF LOADING, SLOPE, AND MOISTURE

CHARACTER-COUNT FOR PROJECT IDENTIFICATION INCLUDES BLANK SPACES. EXAMPLES:

THIS LINE COUNTS 30 CHARACTERS

AND THIS LINE COUNTS 34 CHARACTERS

Figure 3a

## EXPLANATION OF HAZARD APPRAISAL OUTPUT

The output from the hazard appraisal program consists of two parts. The first part restates the debris prediction and the downed woody inventory data so it can be verified (Figure 3b). The slope and the grass loading are also displayed. A 5-year history of fuel bed depth, both for untreated and lopped conditions, is shown. Lopping is presumed done to a "2-foot standard." That is, no limbs extend more than 2 feet off the ground, and no tree boles or large limbs lay more than 1 foot off the ground. The second part of the output consists of tables that describe potential fire behavior. A table is displayed for untreated debris and for lopped debris if lopping is specified. (See Figures 3c and 3d).

### FUEL OUTPUT (Figure 3b)

The first block of fuel numbers lists the input data from the Slash Hazard Form. The input is reprinted so the user can verify the data entries. To emphasize this point, a space is provided on the first page in the upper right corner for the user to initial. The downed woody inventory data input to the program are also shown and should be checked by the user.

The hazard program projects the initial fuel loading data ahead in time for 5 years. During this time, needles and 0- to 1/4-inch twig loadings are reduced. Needle loss is not shown in the output data, but the effect of settling (reduction in depth) is. Because of its importance in determining fire behavior and because so many factors influence it, a special research project was undertaken to find out how to predict the depth of debris. The relationships in the HAZARD model reflect the best available data at the time of this writing. They are subject to change.

The fuel bed depth is the "bulk depth" (Albini and Brown, 1978). On the average the bulk depth is 64% of the average high particle depth. The fuel depths shown in the outputs may be lower than expected. Visual estimates of depth are almost always high because the eye tends to focus on the highest points of the debris. The hazard appraisal program computes the fuel depth that would be observed if the fuel were uniformly spread over the site. Thus, prominent single limbs or tops standing above the average height are discounted, and the depth of a uniform fuel bed of the same average loading and compactness is calculated.

> **Caution**
>
> Do not attempt to run the HAZARD program with a fuelbed consisting only of present dead and down material. Fire behavior outputs will be meaningless. The HAZARD program uses the activity slash predicted by DEBMOD6 in combination with the current fuelbed to predict the fuelbed depth.

Refer to COMPLETING THE SLASH HAZARD FORM for a discussion of moisture percent.

ACTIVITY FUEL FIRE HAZARD ASSESSMENT

INPUT SUBMITTED BY.....

OUTPUT CHECKED BY.....

EXAMPLE FOR USERS' GUIDE

DATE.....

DEBRIS-PREDICTION INPUT DATA ...

| SIZE | SPECIES | LOADING (T/A) BY DBH CLASS 0-1 | 1-2 | 2-3 | 3-4 | 4-5 | 5-6 | 6-7 | 7-8 | 8-9 | 9-11 | 11-13 | 13-15 | 15-17 | 17-19 | 19-25 | 25-30 | 30+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -3IN | DF | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .17 | .16 | .67 | 14.00 |
| 3+IN | DF | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .02 | .02 | .06 | 1.20 |
| CULL | DF | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .08 | .00 | .06 | 5.60 |
| -3IN | GF | .00 | .01 | .07 | .06 | .00 | .00 | .00 | .00 | .00 | 1.30 | .00 | .69 | .00 | 1.50 | .86 | .49 | .24 |
| 3+IN | GF | .00 | .00 | .00 | .02 | .00 | .00 | .00 | .00 | .00 | .38 | .00 | .10 | .00 | .15 | .07 | .02 | .01 |
| CULL | GF | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .82 | .00 | .00 | .00 | .06 | .00 |
| -3IN | WRC | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .32 | .05 | 1.20 |
| 3+IN | WRC | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .01 | .01 | .03 |
| CULL | WRC | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 5.30 |
| CULL | BKG | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 38.00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 |

ACTIVITY-PRODUCED FUELS ... 3 IN AND LESS = 21.8 ... OVER 3 IN = 52.1 ... TOTAL = 73.9

| AVG FUEL DEPTH, FT | NUMBER OF WINTERS 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| UNTREATED SLASH | 1.05 | 1.05 | 1.05 | .92 | .79 |
| LOPPED TO 2-FT STD | .90 | .90 | .90 | .79 | .68 |

DOWN-WOODY INVENTORY ...

| | LOADING IN TONS/ACRE 1 HR | 10HR | 100H | 3-5 | 6-9 | 1020 | 20 + | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| DOWN SOUND | .6 | 1.6 | 3.2 | 1.2 | 2.4 | 7.3 | .0 | 3 IN AND LESS = | 5.4 ... | TOTAL = 16.3 |
| DOWN ROTTEN | | | | .2 | 1.3 | 2.9 | .0 | | ... | TOTAL = 4.4 |

OTHER INPUT DATA ...

NOMINAL GRASS LOADING = .0 MEASURED DUFF LOADING = 15.0 AVERAGE SLOPE (PERCENT) = 0

| FUEL MOISTURE FOR | 1 HR | 10 HR | 100 HR | 1000 HR | DUFF |
|---|---|---|---|---|---|
| (PERCENT DRY WT.) | 5. | 7. | 9. | 12. | 20. |

ACTIVITY ... GROUND-LEAD TIMBER HARVEST UTILIZATION STANDARD = 6.0 INCH TOP RUN 04 APR 80



Figure 3b

FIRE BEHAVIOR OUTPUT (Figures 3c & 3d)

Potential fire behavior is assessed for windspeeds of 0, 5, 10, 15, and 20 mi/h (at standard 20' anemometer exposure) and for debris ages of 1, 3, and 5 years. HAZARD assumes a .5 wind reduction factor to conver the 20-foot wind speed to the mid-flame wind speed. The first table is for untreated debris (Figure 3c); the second (Figure 3d), is for lopped debris. Table format is the same.

Fire behavior variables presented in the tables are based on an upslope wind and upslope fire spread. Assumptions and accuracy of the fire behavior values are discussed in the latter part of this section.

The following descriptions and comparative values will help the user appreciate the significance of the fire behavior values:

1. HEAD FIRE RATE OF SPREAD (CHAINS/HR). -- The values under this heading are maximum rates, rounded to the nearest chain/hour. The wind is assumed to be blowing directly upslope. For comparison purposes, note the following equivalent rates of progress:

- 1 chain/h is about the rate of fireline construction for one man using hand tools in medium fuels (medium resistance to control).

- 10 chains/h is about the rate of fireline construction for a bulldozer working in fuels of extreme resistance to control.

- 100 chains/h is about the speed of a leisurely stroll on level terrain or a good average pace for backpacking in medium to steep terrain.

2. PERIMETER GROWTH RATE (CHAINS/HR). -- Under the conditions cited above, this value is an estimate of the rate of increase in the length of a smooth elliptical outline marking the advancing edge of a fire started at a point (e.g., a spot fire) in the debris. The perimeter growth rate can be viewed as a rough indication of the minimum total line-building rate required to contain a fire.

3. AREA BURNED IN 1 HOUR (ACRES). -- These values give the area burned after 1 hour. Burned area increases with the square of the burning time. To predict the time a fire could stay in the cutting unit, divide half the area of the cutting unit by area burned in 1 hour and take the square root. The result will be the time, in hours, that one could expect the fire to be burning mostly in the cutting unit debris.

4. HEADFIRE FLAME LENGTH (FEET). -- This is the length of flame from the center of the flaming zone at the upper surface of the fuel bed to the tip of the flame. This dimension, with no wind, will be the vertical flame height. In most cases, wind will tilt the flame and the flame length will be the slant distance. Guides for interpreting flame length are included under item 6, below.

5. CROWN SCORCH HEIGHT DUE TO HEAD FIRE (FEET). -- Crown scorch height is calculated from Byram's intensity (see item 6, below). The scorch height value represents the height at which a lethal temperature of 140° F or greater is reached above a spreading head fire. Values are rounded to the nearest foot and assume an ambient temperature of 77° F. While it is possible to adjust for other ambient temperatures (Albini 1976), the accuracy of the estimate in itself does not warrant such a refinement. Lethal scorching implies that the tissue is killed; the scorched needles will turn brown within a few weeks. Cambium kill due to heating alone (with or without crown scorch) is not modeled in HAZARD. Thus, the user should be aware that tree kill may be underestimated if only crown scorch damage is considered. Tree kill from crown scorch may also be underestimated if slope is greater than 50 percent.

6. BYRAM'S INTENSITY FOR THE HEAD FIRE (BTU/S/FOOT). -- This quantity represents the rate of heat release per foot of fire edge at the head of the running fire. It has been used to describe the difficulty of controlling a fire. The list that follows shows numerical values and associated descriptions that may help to interpret this factor. The flame length (item 4, above) derived for each intensity from Byram's formula is also shown.

| Byram's intensity | Flame length | Fire situation |
|---|---|---|
| ≤5 Btu/s/foot | ≤1 ft | Marginal burning. Few fires exist at this level. |
| 20 - 50 Btu/s/ft | 2 - 3 ft | Easily attacked and controlled. People can work right up to the edge of the fire without extra protection. |
| 100 Btu/s/ft | 4 ft | This is about the tolerable limit for people to work at the fire edge. Direct attack with hand crews is impractical above this level of intensity. |
| 500 - 700 Btu/s/ft | 8 - 9 ft | Spotting begins to be a problem and the limit of direct attack by any means is reached in this range of intensities. |
| 1,000 Btu/s/ft | 11 ft | Crowning can be expected to begin. Serious spotting may occur. |
| 20,000 - 30,000 | 40 - 50 ft | Major conflagration. Long-range spotting occurs; tree blowdown may occur. Flaming zone depths of up to 1/4 mile can arise, so the flame length formula is not very useful here. |

7. HEAT LOAD (BTU PER SQUARE FOOT). -- This number represents the total heat release per square foot of surface due to the burning of surface fuels, litter, and duff. It measures the potential combustion energy stored on the site. To interpret this quantity as anything other than an index of fuel accumulation cannot be supported at this time. From physical principles it seems nearly certain that such effects as soil conditioning, seed treatment, root damage, etc., should be related to total energy release on the burned site. Users need to observe vegetative response and other site effects from fires of different heat loads. In this way, a basis for interpreting heat load values can be acquired.

8. BURN TIME (MINUTES). -- This gives a rough estimate of the period of active flaming at the fire front, not the duration of smoldering or the burning time of concentrations of debris. By itself, the burn time is probably not a useful number because it is not related to fire intensity. Used with the heat load value (see item 7, above), we can interpret this number as an indicator of the time after passage of the fire front when people could enter the burned area.

When the heat load is divided by the burn time, the result is an estimate of the rate of heat release per unit area, a measure of fire intensity. Based on the temperature of a flame tip, a fire burning in natural fuels emits about 100 Btu/min/ft . From this we can infer that a ratio of heat load to burn time of about 100 would represent a hazardous situation for firefighting ground crews. This value, like any other average value, must be interpreted in relation to what is on the ground. If debris is spread rather uniformly over the area a value as low as 10 might indicate a hazardous situation. But if debris tends to be concentrated in piles, safe entry might be permitted despite values in excess of 100.

EXAMPLE FOR USERS' GUIDE

UNTREATED SLASH

POTENTIAL FIRE BEHAVIOR

| QUANTITY ASSESSED | 20-FT. WIND MI/H | SLASH AGE IN NUMBER OF WINTERS 1 | 3 | 5 |
|---|---|---|---|---|
| ..... | 0 | 1 | 0 | 0 |
| HEAD FIRE | 5 | 2 | 2 | 1 |
| SPREAD RATE | 10 | 5 | 4 | 2 |
| CHAINS/HOUR | 15 | 8 | 6 | 3 |
| ..... | 20 | 12 | 9 | 4 |
| ..... | 0 | 3 | 2 | 1 |
| PERIMETER | 5 | 8 | 6 | 4 |
| GROWTH RATE | 10 | 14 | 11 | 6 |
| CHAINS/HOUR | 15 | 20 | 15 | 8 |
| ..... | 20 | 24 | 18 | 9 |
| ..... | 0 | 0 | 0 | 0 |
| BURNED AREA | 5 | 0 | 0 | 0 |
| AFTER 1 HOUR | 10 | 2 | 1 | 0 |
| BURN, ACRES | 15 | 3 | 2 | 1 |
| ..... | 20 | 5 | 3 | 1 |
| ..... | 0 | 3 | 2 | 2 |
| HEAD FIRE | 5 | 5 | 4 | 3 |
| FLAME LENGTH | 10 | 7 | 6 | 4 |
| IN FEET | 15 | 9 | 8 | 5 |
| ..... | 20 | 11 | 9 | 6 |
| ..... | 0 | 15 | 11 | 8 |
| CROWN SCORCH | 5 | 28 | 20 | 11 |
| HEIGHT IN FT | 10 | 33 | 21 | 10 |
| BY HEAD FIRE | 15 | 35 | 21 | 9 |
| ..... | 20 | 37 | 21 | 8 |
| ..... | 0 | 57 | 37 | 20 |
| INTENSITY AT | 5 | 206 | 141 | 78 |
| HEAD OF FIRE | 10 | 450 | 293 | 142 |
| (BTU/SEC/FT) | 15 | 750 | 471 | 210 |
| ..... | 20 | 1093 | 667 | 279 |

RESIDUAL FIRE FROM BURNOUT OF LARGER FUELS (AND DUFF)

| | | | |
|---|---|---|---|
| HEAT LOAD (BTU/SQFT) | 26111 | 24843 | 24150 |
| BURN TIME (MINUTES) | 67 | 67 | 67 |

GRD. LEAD HARVEST UTL. STD. 6.0 IN RUN 04 APR 80

Figure 3c

EXAMPLE FOR USERS' GUIDE
LOPPED TO 2-FT STD
POTENTIAL FIRE BEHAVIOR

| QUANTITY ASSESSED | 20-FT. WIND MI/H | SLASH AGE IN NUMBER OF WINTERS 1 | 3 | 5 |
|---|---|---|---|---|
| ..... | 0 | 0 | 0 | 0 |
| HEAD FIRE | 5 | 2 | 1 | 1 |
| SPREAD RATE | 10 | 4 | 3 | 2 |
| CHAINS/HOUR | 15 | 6 | 5 | 2 |
| ..... | 20 | 9 | 7 | 3 |
| ..... | 0 | 2 | 2 | 1 |
| PERIMETER | 5 | 6 | 5 | 3 |
| GROWTH RATE | 10 | 10 | 8 | 5 |
| CHAINS/HOUR | 15 | 15 | 11 | 6 |
| ..... | 20 | 18 | 14 | 7 |
| ..... | 0 | 0 | 0 | 0 |
| BURNED AREA | 5 | 0 | 0 | 0 |
| AFTER 1 HOUR | 10 | 1 | 1 | 0 |
| BURN, ACRES | 15 | 2 | 1 | 0 |
| ..... | 20 | 3 | 2 | 0 |
| ..... | 0 | 3 | 2 | 2 |
| HEAD FIRE | 5 | 5 | 4 | 3 |
| FLAME LENGTH | 10 | 7 | 5 | 4 |
| IN FEET | 15 | 8 | 7 | 5 |
| ..... | 20 | 10 | 8 | 5 |
| ..... | 0 | 13 | 10 | 6 |
| CROWN SCORCH | 5 | 22 | 15 | 8 |
| HEIGHT IN FT | 10 | 24 | 15 | 7 |
| BY HEAD FIRE | 15 | 26 | 15 | 6 |
| ..... | 20 | 26 | 15 | 5 |
| ..... | 0 | 45 | 29 | 16 |
| INTENSITY AT | 5 | 155 | 106 | 57 |
| HEAD OF FIRE | 10 | 335 | 219 | 103 |
| (BTU/SEC/FT) | 15 | 557 | 350 | 151 |
| ..... | 20 | 811 | 496 | 201 |

RESIDUAL FIRE FROM BURNOUT OF LARGER FUELS (AND DUFF)

| | | | |
|---|---|---|---|
| HEAT LOAD (BTU/SQFT) | 26111 | 24843 | 24150 |
| BURN TIME (MINUTES) | 67 | 67 | 67 |

GRD. LEAD HARVEST UTL. STD. 6.0 IN RUN 04 APR 80

Figure 3d

## ASSUMPTIONS AND ACCURACY OF HAZARD APPRAISAL

The hazard appraisal program, in its present form, is intended to be used in planning. The numbers produced by the HAZARD program must be interpreted by trained people. In this way, the absolute values can be reduced to meaningful indexes, perhaps adjective ratings. The greatest strength of the hazard appraisal program is in providing an objective means of using fuel estimates in a planning exercise. Because the program uses new research, the absolute values are often not all that accurate. Some are more accurate than others, for example: rate of spread and intensity are probably the most reliable values provided. Limitations of the program and estimate of accuracy are given in the remainder of this section.

The program was not designed for the establishment of burning prescriptions. For recommendations and guidelines for establishing such prescriptions refer to:

1. Planning for Prescribed Burning in the Inland Northwest by Robert E. Martin and John D. Dell (1978), USDA, Forest Service, Pacific Northwest Forest and Range Exp. Sta.

2. Preliminary Guidelines for Prescribed Burning Under Standing Timber in Western Larch/Douglas-Fir Forests by Rod Norum (1977), Intermountain Forest and Range Experiment Station.

3. Planning and Evaluating Prescribed Fires - A Standard Procedure by Bill Fischer (1978), Intermountain Forest and Range Experiment Station.

### BASIC ASSUMPTIONS

The following assumptions are made in the formulation of the fire behavior prediction equations. They should be kept in mind when using the fire behavior numbers.

1. Predicted debris represents the dominant fire-carrying fuels on the site. The computer has no way of knowing if this assumption is, in fact, true for the situation being evaluated by the user. If fuels other than those used as inputs to the hazard program, such as shrubs from shrub dominated habitat types, are likely to have a significant influence in the stand after cutting, the fire behavior predictions must be discounted accordingly.

2. Living vegetation on the site (which may either enhance or hinder the rate of fire spread and increase or decrease fire intensity) is not considered in the program. The effect of conifer reproduction that has been trampled or slashed can be approximated, however, by including small trees (from the debris potential output) in the input to the hazard appraisal program. If grass, forbs, or living shrubs are important to fire behavior on the site, other methods of estimating fire behavior such as the fire behavior nomograms developed by Albini (1976) must be employed.

3. The debris is assumed to be spread uniformly over the site. Fuel accumulations, whether due to intentional piling, incidental windrowing (e.g., along skid lanes) or chance "jackpot" concentrations often occur. Fire in these atypical loadings will not behave in the same way as will fire in the "average" loading. This source of variation in fire behavior may differ greatly from site to site. The user must use judgment to assess this variation.

## ACCURACY OF PREDICTIONS

The accuracy of the fire behavior values is not as great as that of the debris prediction values. The user should not expect predicted fire behavior values to be absolute indicators of values observed on an actual fire under comparable conditions. The predictions should, none the less, provide approximate values likely to be observed on an actual fire under comparable conditions. This caution is not meant to discourage use of the fire behavior numbers. Just remember, the power of the Hazard Appraisal Program is in the magnitude and the relative nature of the predicted fire behavior numbers, not their absolute value.

The accuracy of fire behavior predictions depends on the accuracy of the fuel input (debris prediction) and of the fire behavior models used in the computer programs. A summary of the accuracy of the predictions based only on these factors follows:

1. HEAD FIRE RATE OF SPREAD. -- Deviations from the predicted values should be expected, even when input data are representative of the actual conditions. A range of actual spread rates from 1/2 to 2 times the predicted values is to be expected. Values of from 1/4 to 4 times the predicted values may occur. Only very rarely should the actual value be less than 1/10 or more than 10 times the prediction.

2. PERMIMETER GROWTH RATE. -- Only a few lab tests and a limited number of field examples provide the basis for the perimeter growth rate calculation. Prediction of this growth rate depends on calculation of rate of spread, and the accuracy of this spread rate contributes the greatest uncertainty in determining perimeter growth. Thus, the accuracy of the perimeter growth rate is about the same as for rate of spread (see item 1, above). The perimeter estimated here is the smooth outline of a roughly elliptical shape. It in no way is meant to reflect the details of a ragged outline of an actual fire.

3. AREA BURNED IN 1 HOUR. -- The basis for this calculation is the same as for the perimeter growth item (item 2, above), so the cautions listed above apply. The area burned over in a given time is proportional to the square of the forward rate of spread. Therefore, the uncertainty in the value of the computed burned area is amplified by this relationship of spread rate and area. Deviations from predicted values in the range 1/4 to 4 times are to be expected, and variations within the extremes of 1/10 to 10 times the predicted value may occur occasionally.

4. FLAME LENGTH AT THE HEAD OF THE FIRE. -- The head fire flame length is calculated from the head fire of Byram's intensity. The length of the flame is different from its vertical height or its horizontal reach, and the value given is an average estimate, not a maximum or minimum. Flame length will have an accuracy that should be about the same as for rate of spread. That is, it can be expected to vary from 1/2 to 2 times the value given. Flame lengths less than 2 feet imply that debris is not the main fire carrier. The user should check to see if grass, shrubs, litter, or dead fuels not entered in the program are prevalent on the site.

5. CROWN SCORCH HEIGHT DUE TO HEAD FIRE. -- Although meant to imply a maximum scorch height, lethal scorching above the calculated scorch height can occur. Predictions of crown scorch height and their accuracy depend on fuel amount and how the fuel is distributed over the area. The assumption of uniform fuels used in the model will cause some inaccuracy. These inaccuracies should be about the same as for flame length and rate of spread.

When comparing scorch height and flame length, remember that flame length may be a slant measurement and not a vertical height measurement. Under high wind, flame length may exceed scorch height because heat is being carried away rather than rising up to the tree crowns.

If the slope is 50 percent or greater, the scorch height may be badly underestimated; crown scorch may occur a significant distance upslope from the burned area. Additional tree damage can occur through cambium kill and/or root damage. While no attempt has been made to model these effects, the user may find the total heat load figure (see item 7, below) a useful guide to inferring the potential for such damage.

6. BYRAM'S INTENSITY FOR THE HEAD FIRE. -- The theory behind this calculation is sound. It is based upon knowing head fire rate of spread so accuracies in the intensity will be the same as expected for rate of spread.

7. HEAT LOAD. -- The theory for heat release per unit area was developed from available data. More work needs to be done so results should be used with caution. Heat load is highly sensitive to duff moisture so consumption of duff and surface fuels will vary accordingly. For the average duff moisture of 25 percent, as assumed in the program, the heat load value is expected to be accurate to about ±40 percent.

8. BURN TIME. -- The formula used for this calculation is based on empirical data described in research literature. The figure is probably accurate to ±40 percent, but no direct evidence of precision is available. More work is needed so use with caution.

When forming the ratio of heat load to burn time, the result should be viewed as an estimate that can, with equal likelihood, be 1/2 to 2 times the value it should be.

HAZARD'S ADP PROGRAM WRITEUP

The following "runstream" will enable Forest and District personnel to use the HAZARD appraisal program with either a low or high speed terminal.

Program Description

| | |
|---|---|
| PROGRAM | CSSG*R1LIB.HAZARD |
| LANGUAGE | FORTRAN V |
| MACHINE | FCCC UNIVAC 1100 |
| USAGE | DEMAND OR BATCH<br>(132 CHARACTER TERMINAL) |

## HIGH SPEED TERMINAL

Fill out the Slash Hazard Form using the instructions contained in Section III of this guide. Determine if your Forest has high speed computer capability. If so, submit completed forms to the Forest Computer Specialist for processing.

Keypunch instructions are found in Appendix IV.

## LOW SPEED TERMINAL

The Slash Hazard Form has been designed to be used in conjunction with the following instructions for creating a data file interactively from a low speed terminal. Data taken from the output of the Debris Prediction System is transferred to the Slash Hazard Form (Figure 3a) following the directions presented in Section III, 'Completing the Slash Hazard Data Form. It may be helpful to refer to this section for a clarification of terms used when creating a data file. Note that the symbol ∅ is to indicate a blank.

Before entering the runstream, create a data file using the following instructions:

A four letter code is used to identify the data entry as follows:

PROJECT IDENTIFICATION - PROJ
UTIL.STD. - UTIL
HELICOPTER OR SKYLINE - HELI
LOP DEBRIS - LOP∅
MOISTURE % - MOIS
-3IN - -3IN
3+IN - 3+IN
CULL - CULL
DOWN FUELS - DOWN
GRASS LOAD - GRAS
SLOPE PCT - SLOP

The program edits these so if in error, it will not be put in the formatted data file. After each four letter title, leave one blank space and type in whatever data is required for that card. The only exceptions are -3IN, 3+IN, CULL, and DOWN.

-3IN, 3+IN, CULL, DOWN

For -3IN, 3+IN, CULL, AND DOWN, the D.B.H. classes in inches are given a field number. The field number is correlated with the D.B.H. class on the form in figure 3a.

| D.B.H. class | 0-1 | 1-2 | 2-3 | ... | 25-30 | 30+ |
|---|---|---|---|---|---|---|
| Field | 01 | 02 | 03 | ... | 16 | 17 |

Leading zeros for the field numbers must be entered. Only those field containing data need to be entered.

The following example:

| Field | 02 | 03 | 04 | 10 | 12 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|
| DBH class | 1-2 | 2-3 | 3-4 | 9-10 | 13-15 | 17-19 | 19-25 | 25-30 | 30+ |
| 0-3 in. GF fuel loading | .01 | .07 | .06 | 1.3 | .69 | 1.5 | .86 | .49 | .24 |

would be typed as:

-3IN␣GF␣02.0103.0704.06101.312.69141.515.8616.4917.24

The same procedure applies to 3+IN, CULL, and DOWN.

CAUTION: When using a 3 letter species code (WRC, WWP, WBP), do not follow it by a ␣. Immediately enter the data. For the example in figure 3a, the following is correct:

-3IN␣WRC15.3216.05171.2

For the example in figure 3a, DOWN would be typed as follows:

DOWN␣01.63021.6033.2041.2052.4067.308.15091.3102.91215.

Utilization Standard

Type in UTIL␣. The next 3 characters are the utilization standard. A 6" Utilization Standard would be entered as: UTIL␣6.0

Lopping

If you wish an estimate of the fire behavior following lopping of slash to a 2-foot standard, enter LOP␣.

For CULL BKG, just enter the loading rounded to the nearest unit. The computer will automatically place it in the 8-9 in. DBH class. For the example in figure 3a, the CULL BKG would be typed as follows;

CULL␣BKG38.

Fuel Moistures

To enter moisture contents which differ from the default values, the percent moisture is entered in order for the 1-hr., 10-hr., 100-hr., and 1000-hr., timelag fuel classes and Duff. The following moisture contents

| | 1-hr. | 10-hr. | 100-hr. | 1000-hr. | Duff |
|---|---|---|---|---|---|
| %Mx | 7 | 10 | 20 | 30 | 50 |

would be entered as follows:

MOIS␣7.010.20.30.50.

Skidding

Entering HELI for helicopter represents both helicopter and skyline skidding. Default represents ground or no skidding. For precommercial thinning enter a utilization standard of 0 and use the default (no skidding) option.

Grass Loading

For the Grass loading, type as follows:

For a heavy grass loading, GRAS␣1.
For a medium grass loading, GRAS␣.
The default grass loading is little or none.

Percent Slope

To enter the slope, type SLOP␣. The next 3 entries should be the percent slope. For example, a 30 percent slope would be typed as SLOP␣030.

The last command in the file must be STOP. A STOP␣1 will give a listing of the formated data. This completes the data file for one project. More than one project can be entered at a time by repeating the instructions for each project.

To run the data through this formatting program, use the following runstream either in DEMAND or use a START or ADD file for a BATCH run.

```
@FREE␣Input file name.
@@TTY␣W,132
@ASG,A␣Input file name.
@USE␣3.,␣Input file name.
@ASG,UP␣Output file name.
@USE␣2.,␣Output file name.
@XQT␣R*FS.SLASH
@ASG,A␣CSSG*RILIB.
@XQT␣CSSG*RILIB.HAZARD
@ADD,E␣Output file name.
```

Samples of files INPUT and OUTPUT, and an example for following the runstream are shown on the next two pages.

```
.UQL403
*UNIVAC 1100 OPERATING SYSTEM  LEV. 36-R1-4C     (RSI)*
>@RUN R06DWC,
DATE: 032880  TIME: 200743
Graphics Users, check INFO subject Graphics, everyone
else, look at subject OPERATIONS....
>@ASG, CP EMILY.
READY
>@ED, I EMILY.
CASE UPPER ASSUMED
ED 15R2-FRI-03/28/80-20:08:54-(,0)
INPUT
1I:>PROJ EXAMPLE FOR USERS' GUIDE
2I:>UTIL 6.0
3I:>LOP
4I:>-3IN DF 14.1715.1616.671714.
5I:>3+IN DF 14.0215.0216.06171.2
6I:>CULL DF 14.0816.06175.6
7I:>-3IN GF 02.0103.0704.06101.312.69141.515.8616.4917.24
8I:>3+IN GF 04.0210.3812.1014.15 15.0716.0217.01
9I:>CULL GF 12.8216.06
10I:>-3IN WRC15.3216.05171.2
11I:>3+IN WRC15.0116.0117.03
12I:>CULL WRC175.3
13I:>CULL BKG38.
14I:>DOWN 01.63021.6033.2041.2052.4067.308.15091.3102.91215.
15I:>SLOP 000
16I:>STOP
17I:>
EDIT
16:>EXIT
LINES:16 FIELDATA
>@FREE EMILY.
READY
>@@TTY W,132
->
-@@COMPLETE
@ASG,A EMILY.
READY
>@USE 3., EMILY.
READY
>@ASG,UP EMILYOUT.
READY
>@USE 2., EMILYOUT.
READY
>@XQT R*FS.SLASH
 EOF DETECTED - - JOB FINISHED


>@ASG,A CSSG*R1LIB.
FACILITY WARNING  000200000000


>@XQT CSSG*R1LIB.HAZARD
>@ADD,E EMILYOUT.
```

AT THIS POINT THE PROGRAM WILL PRINT OUT THE OUTPUT (REFER TO FIGURES 3b, c, and d). HOWEVER, IF THERE IS AN ERROR IN THE MASS STORAGE FILE FOR OUTPUT, AN ERROR MESSAGE WILL BE PRINTED OUT. TO CORRECT ERRORS CALL THE OUTPUT FILE (IN THIS EXAMPLE, EMILYOUT) USING THE EDITOR AND MAKE CORRECTIONS AS SHOWN BELOW:

```
>ED,U EMILYOUT.
CASE UPPER ASSUMED
ED 15R2-FRI-04/20/79-11:47:32-(0,1)
EDIT
0>LNP!
      1:EXAMPLE FOR USERS' GUIDE
      2:UTIL. STD.6.0
      3:LOP DEBRIS                                                    .17.16.6714.
      4:-3IN DF                                                       .02.02.061.2
      5:3+IN DF                                                       .08   .065.6
      6:CULL DF
      7:-3IN GF        .01.07.06                  1.3    .69          .15.86.49.24
      8:3+IN GF              .02                  .38    .10          .51.07.02.01
      9:CULL GF                                          .82                .06
     10:-3IN WRC                                                           .32.051.2
     11:3+IN WRC                                                           .01.01.03
     12:CULL WRC                                                                5.3
     13:CULL BKG                                38.
     14:DOWN FUELS.631.63.21.22.47,3  .151.32.9    015
     15:SLOPE PCT 000
     16:
     17:QUIT
EOF:17
0>EXIT
LINES:17 FIELDATA
```

ONCE CORRECTIONS ARE MADE, REEXECUTE THE HAZARD PROGRAM USING THE LAST TWO LINES OF THE RUNSTREAM.

# REFERENCES

## REFERENCES


Albini, Frank A.
1976. Computer-based models of wildland fire behavior: a users' manual. USDA For. Serv., Intermt. For. and Range Exp. Stn., 68 p. Ogden, Utah.

Albini, Frank A.
1976. Estimating wildfire behavior and effects. USDA For. Serv. Gen. Tech. Rep. INT-30, 92 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Albini, Frank A., and James K. Brown.
1978. Predicting slash depth for fire modeling. USDA For. Serv. Res. Pap. INT-206, 22 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Anderson, Hal E.
1978. Graphic Aids for field calculation of dead, down forst fuels. USDA, For. Serv., Gen. Tech. Report INT-45, 20 pp., illus. Intermountain Forest & Range Exp. Sta., Ogden, Utah.

Brown, James K.
1978. Weight and density of crowns of Rocky Mountain conifers. USDA For. Serv. Res. Pap. INT-197, 56 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Brown, James K. and Cameron M. Johnston.
1976. Debris prediction system. Office report on file at Northern Region Fire Laboratory, USDA For. Serv. Intermt. For. and Range Experiment Station, 27 p.

Brown, James K., J. A. Kendall Snell, and David L. Bunnell.
1977. Handbook for predicting slash weight of western conifers. USDA For. Serv. Gen. Tech. Rep. INT-37 35 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Brown, James K.
1974. Handbook for Inventorying Downed Woody Material. USDA, Forest Service, Gen. Tech. Rep. INT-16, 24 p. Intermt. Forest and Range Exp. Stn., Ogden, Utah.

Dilworth, J. R.
1972 Log Scaling and Timber Cruising. O.S.U. Bookstores, Inc. Corvallis, Oregon 470 pp., illus.

Faurot, James L.
1977. Estimating merchantable volume and stem residue volume in four northwest timber species: ponderosa pine, lodgepole pine, western larch, Douglas-fir. USDA For. Serv. Res. Pap. INT-196, 55 p. Intermt. For. and Range Exp. Station, Ogden, Utah.

Fischer, William C.
1978. Planning and evaluating prescribed fires--a standard procedure. USDA For. Serv. Gen. Tech. Rep. INT-43, 19 p. Intermt. Forest and Range Experiment Station, Ogden, Utah.

Martin, Robert E. and Dell, John D.
1978. Planning for prescribed burning in the inland Northwest. USDA, Forest Service, Gen. Tech. Report PNW-76, 67 p. illus. Pac. NW Forest & Rge. Exp. Sta., Portland, Oregon.

Maxwell, Wayne G. and Ward, Franklin R.
1976. Photo Series for quantifying forest residues in the: Coastal Douglas-fir-Hemlock type and Coastal Douglas-fir-Hardwood type. USDA, Forest Service, Gen. Tech. Report PNW-51. 103 p., illus. PNWF&RES, Portland, Oregon.

Maxwell, Wayne G. and Ward, Franklin R.
1976. Photo Series for quantifying forest residues in the: Ponderosa Pine Type, Ponderosa Pine and Associated Species Type, and the Lodgepole Pine Type. USDA, Forest Service, Gen. Tech. Report PNW-52. 73 p., illus. PNWF&RES, Portland, Oregon.

Maxwell, Wayne G. and Ward, Franklin R.
1980. Photo Series for quantifying natural forest residues in common vegetation types of Pacific Northwest. USDA, Forest Service, Gen. Tech. Report PNW-105. 230 p., illus. PNWF&RES, Portland, Oregon.

Norum, Rodney A.
1977. Preliminary guidelines for prescribed burning under standing timber in the larch/Douglas-fir types. USDA For. Serv. Res. Note INT-229, 15 p. Intermt. For. and Range Exp. Sta., Ogden, Utah.

Rothermel, Richard C.
1972. A mathematical model for predicting fire spread in wildland fuels. USDA For. Serv. Res. Pap. INT-115, 40 p. Intermt. For and Range Experiment Station, Ogden, Utah.

USDA Forest Service.
(n.d.) Prescribed burning guide. USDA Forest Service, Northern Region Fuel Management Planning and Treatment Guide, 56 p., Missoula, Montana.

# APPENDIX

## APPENDIX I

### TABLE OF RANDOM AZIMUTHS FOR PLANAR INTERSECT FUEL SAMPLING

| | | | | |
|---|---|---|---|---|
| L30 | L30 | L60 | L150 | L30 |
| L120 | L90 | L120 | 0 | L150 |
| 0 | L60 | R90 | R60 | 0 |
| 0 | L120 | L60 | L150 | R30 |
| R30 | 130 | 0 | L150 | R150 |
| R120 | L150 | L90 | R90 | R60 |
| L90 | R120 | 0 | R30 | L90 |
| L90 | R120 | L150 | L150 | R120 |
| L90 | L120 | L60 | 0 | R120 |
| L120 | R120 | R150 | L30 | L120 |
| L30 | R30 | L90 | R90 | L30 |
| L30 | R90 | R90 | L90 | L90 |
| 0 | 0 | 0 | R120 | R30 |
| L90 | R150 | L30 | R120 | L30 |
| R120 | 0 | L150 | 0 | 0 |
| R150 | L60 | L60 | 0 | R150 |
| L60 | L90 | R120 | R120 | R120 |
| R30 | 0 | L90 | 0 | R30 |
| R120 | R60 | R90 | L90 | L120 |
| R30 | R30 | R30 | L60 | 0 |
| 0 | 0 | R30 | L90 | L30 |
| L120 | L150 | L60 | L60 | L30 |
| L60 | R30 | L60 | L90 | L150 |
| L30 | L30 | L150 | L90 | L150 |
| L150 | R30 | L120 | R120 | 0 |

NOTE: L=Left of Azimuth R=Right of Azimuth
Azimuths generated from random number generator where odd digit indicates left, even digit indicates right and Azimuth indicated by:
1=0°, 2=30°, 3=60°, 4=90°, 5=120°, and 6=150°

## APPENDIX II

### SOURCES FOR DEBMOD MODIFICATIONS FOR DEBMOD6

The functions and relationships needed to make debris estimates come from many sources. For trees west of the Cascade Mountains, Brown's (1977) live branchwood weight functions were used to their sample data limit, except for Douglas-fir and western hemlock. For these two species, Pacific Northwest equations[1/] are used for trees of all d.b.h.'s. The Douglas-fir equation for the Pacific Northwest is also adjusted and used to estimate live branchwood weight for all other species beyond Brown's data. For Douglas-fir dead branchwood weight a Pacific Northwest equation is used for all d.b.h.'s, and is also adjusted and used for all other species and d.b.h.'s.

For trees east of the Cascade Mountains, Brown's (1977) live and dead branchwood weight functions were used to their sample data limit. Beyond that limit, for live weight, the Pacific Northwest Douglas-fir equation is adjusted and used for all species. For dead branchwood weight, Brown's (1977) equations are used to their data limit and then held constant.

Unmerchantable tip volumes of 4-, 5-, 6-, 7-, and 8-inch diameter are calculated using Faurot's (1977) equations up to their data limit and then held constant. For 9-inch and Girard unmerchantable tip weights, a geometric approach is used.

Cull, which includes cull trees and estimated defect of merchantable trees, is calculated by multiplying the merchantable tree volume by percent defect. Both volume and percent defect are estimated by the Stand Examination process.

The programming was written by Roger McCluskey and Cameron Johnston, Northern Forest Fire Laboratory, and modified for Region 6 by Cameron Johnston and Jim Atkins from Pacific Northwest Forest and Range Experiment Station.

---

1/ On file at the Pacific Northwest Forest and Range Experiment Station, Forest Residues Program, Portland, Oregon

## APPENDIX III

### DENSITIES OF COMMON WESTERN TREE SPECIES

| Species | Densities lb/cu.ft. | Species | Densities lb./cu.ft. |
|---|---|---|---|
| Douglas-fir | 30 | Noble fir | 24 |
| Hemlock, western | 28 | Pacific silver fir | 27 |
| Port-Orford cedar | 27 | Subalpine fir | 20 |
| Western red cedar | 20 | White fir | 24 |
| Incense cedar | 23 | Tanoak | 36 |
| Western larch | 32 | Old-growth redwood | 31 |
| Lodgepole pine | 26 | Black spruce | 25 |
| Ponderosa pine | 25 | Englemann spruce | 22 |
| Sugar pine | 22 | Red spruce | 26 |
| Western white pine | 24 | Sitka spruce | 25 |
| Balsam fir | 22 | White spruce | 25 |
| California red fir | 21 | Western Larch (Tamarack) | 33 |
| Grand fir | 23 | | |

APPENDIX IV

KEYPUNCHING INSTRUCTIONS FOR HIGH SPEED TERMINAL

| CARD PUNCHING & VERIFYING INSTRUCTIONS | Symbol | *Function | PROGRAM NAME HAZARD | |
|---|---|---|---|---|
| | D | Duplicate | PROGRAM NUMBER 5100-040 | DATE 12/6/78 |
| | P | Punch | | |
| | S | Skip | SOURCE DOCUMENT CARD FORM USED R1-5100-4 | |
| | V | Verify | | |
| | L | Left justify | PREPARED BY C. Johnston | PAGE 1 of 4 |

| CARD FIELD | COLUMNS FROM | COLUMNS TO | NO. COLS. | FUNC. * | REMARKS |
|---|---|---|---|---|---|
| Project identification | 1 | 48 | 48 | P | Alpha-numeric |
| | | | | | |
| Utility standard | 1 | 10 | 10 | P | Punch "UTIL. STD." |
| Merchantable top | 11 | 13 | 3 | P | Numeric-include decimal |
| Next three cards - only when requested | | | | | |
| Helicopter or Skyline | 1 | 10 | 10 | P | Punch "Helicopter" |
| | | | | | |
| LOP DEBRIS | 1 | 10 | 10 | P | Punch "LOP DEBRIS" |
| | | | | | |
| Moisture | 1 | 8 | 8 | P | Punch "MOISTURE" |
| | 9 | 10 | 2 | S | |
| 1 HR | 11 | 13 | 3 | P | Numeric - include |
| 10 HR | 14 | 16 | 3 | P | decimal - blank |
| 100 HR | 17 | 19 | 3 | P | for no entry |
| 1000 HR | 20 | 22 | 3 | P | |
| DUFF | 23 | 25 | 3 | P | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

APPENDIX IV (Continued)

| CARD PUNCHING & VERIFYING INSTRUCTIONS<br><br>LOADING | Symbol | *Function | PROGRAM NAME | |
|---|---|---|---|---|
| | D | Duplicate | PROGRAM NUMBER | DATE |
| | P | Punch | | |
| | S | Skip | SOURCE DOCUMENT CARD FORM USED | |
| | V | Verify | | |
| | L | Left justify | PREPARED BY | PAGE 2 of 4 |

| CARD FIELD | COLUMNS FROM | COLUMNS TO | NO. COLS. | FUNC. * | REMARKS |
|---|---|---|---|---|---|
| Size | 1 | 4 | 4 | P | "-3IN", "3+IN", "CULL", |
| | | | | | "BKG" as indicated |
| | | 5 | 1 | S | |
| Species | 6 | 8 | 3 | P | Alpha-left justify |
| | 9 | 10 | 2 | S | |
| DBH 0-1 | 11 | 13 | 3 | P | Numeric - include |
| 1-2 | 14 | 16 | 3 | P | decimal points |
| 2-3 | 17 | 19 | 3 | P | blank for no |
| 3-4 | 20 | 22 | 3 | P | entry |
| 4-5 | 23 | 25 | 3 | P | |
| 5-6 | 26 | 28 | 3 | P | |
| 6-7 | 29 | 31 | 3 | P | |
| 7-8 | 32 | 34 | 3 | P | |
| 8-9 | 35 | 37 | 3 | P | |
| 9-11 | 38 | 40 | 3 | P | |
| 11-13 | 41 | 43 | 3 | P | |
| 13-15 | 44 | 46 | 3 | P | |
| 15-17 | 47 | 49 | 3 | P | |
| 17-19 | 50 | 52 | 3 | P | |
| 19-25 | 53 | 55 | 3 | P | |
| 25-30 | 56 | 58 | 3 | P | |
| 30+ | 59 | 61 | 3 | P | |

| CARD PUNCHING & VERIFYING INSTRUCTIONS | Symbol | *Function | PROGRAM NAME | |
|---|---|---|---|---|
| | D | Duplicate | PROGRAM NUMBER | DATE |
| | P | Punch | | |
| | S | Skip | SOURCE DOCUMENT CARD FORM USED | |
| | V | Verify | | |
| | L | Left justify | PREPARED BY | PAGE 3 of 4 |

| CARD FIELD | COLUMNS FROM | COLUMNS TO | NO. COLS. | FUNC. * | REMARKS |
|---|---|---|---|---|---|
| Down fuels | 1 | 10 | 10 | P | Punch "DOWN FUELS" |
| | | | | | if there are entries in |
| | | | | | columns 11-46 otherwise omit |
| | | | | | card |
| Loadings | | | | | |
| 0-25 | 11 | 13 | 3 | P | Numeric - include |
| 25-1 | 14 | 16 | 3 | P | decimal points - |
| 1-3 | 17 | 19 | 3 | P | blank for no |
| Sound 3-6 | 20 | 22 | 3 | P | entry |
| 6-10 | 23 | 25 | 3 | P | |
| 10-20 | 26 | 28 | 3 | P | |
| 20+ | 29 | 31 | 3 | P | |
| Rotten 3-6 | 32 | 34 | 3 | P | |
| 6-10 | 35 | 37 | 3 | P | |
| 10-20 | 38 | 40 | 3 | P | |
| 20+ | 41 | 43 | 3 | P | |
| Duff | 44 | 46 | 3 | P | |
| | | | | | |
| Grass Load | 1 | 10 | 10 | P | Punch "GRASS LOAD" |
| | | 11 | 1 | P | "1" if indicated |
| | | | | | |
| | | | | | |

APPENDIX IV (Continued)

| CARD PUNCHING & VERIFYING INSTRUCTIONS | Symbol | *Function | PROGRAM NAME | |
|---|---|---|---|---|
| | D | Duplicate | PROGRAM NUMBER | DATE |
| | P | Punch | | |
| | S | Skip | SOURCE DOCUMENT CARD FORM USED | |
| | V | Verify | | |
| | L | Left justify | PREPARED BY | PAGE 4 of 4 |

| CARD FIELD | COLUMNS FROM | COLUMNS TO | NO. COLS. | FUNC. * | REMARKS |
|---|---|---|---|---|---|
| Slope | 1 | 10 | 10 | P | Punch "SLOPE, PCT" |
| | 11 | 13 | 3 | P | Numeric - |
| | | | | | include decimal point |
| | | | | | |
| After last project to be run insert a blank card followed by | | | | | |
| QUIT | 1 | 4 | 4 | P | Punch "QUIT" |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

# APPENDIX V

## Sample Forms

R6 Fuel Inventory Cover Card

R6 Fuel Inventory Plot Card

Debris Potential Summary Form

Slash Hazard Data Form

USDA-FOREST SERVICE **REGION 6**

# FUEL INVENTORY PLOT CARD

UNIT NAME _____ UNIT NO._____ SURVEY_____

P | | | PLOT NUMBER AND SLOPE (%)

%

| | | | PARTICLE COUNT

0-1/4 1/4-1 1-3

| SPP. | | RECORDED DIAMETERS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ϕ | | | | | | | | | | | | |
| | ϕ | | | | | | | | | | | | |
| | ϕ | | | | | | | | | | | | |
| | ϕ | | | | | | | | | | | | |
| | ϕ | | | | | | | | | | | | |
| | ϕ | | | | | | | | | | | | |
| | ϕ | | | | | | | | | | | | |
| | ϕ | | | | | | | | | | | | |
| | ϕ | | | | | | | | | | | | |
| | ϕ | | | | | | | | | | | | |

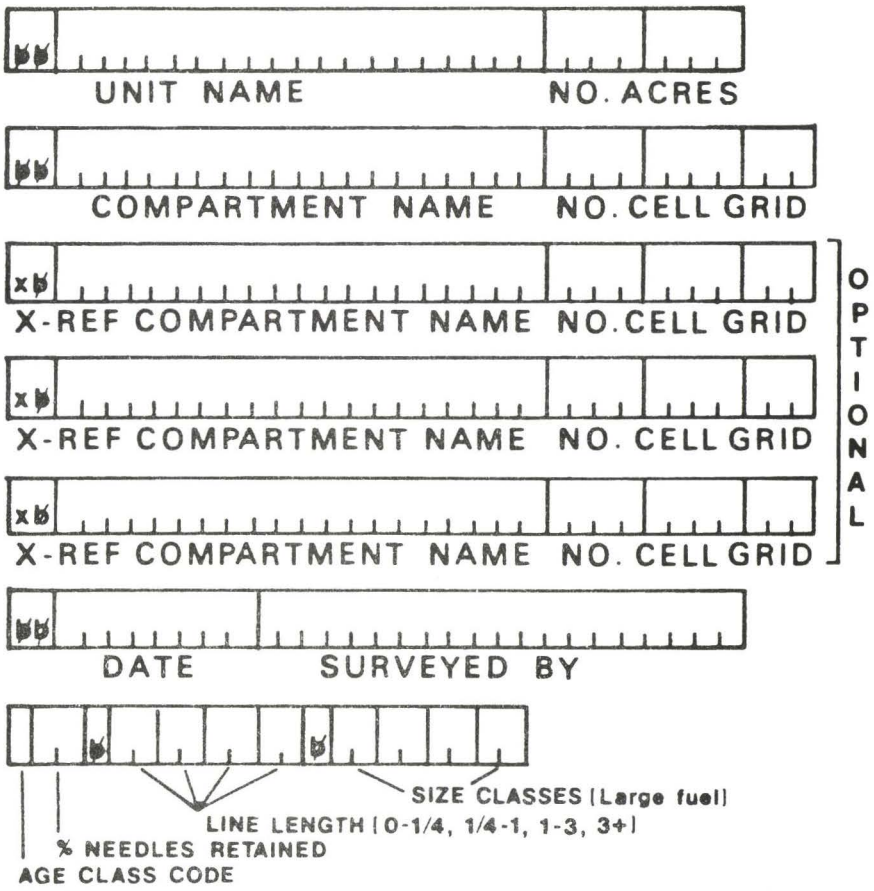
0,0,0 ϕ | | | | FUEL BED DEPTH (inch)

0,0,0 ϕ | | | DUFF DEPTH (1/10 inch)

R6-5150-126a (6/79)

USDA-FOREST SERVICE **REGION 6**

# FUEL INVENTORY COVER CARD




AGE CLASS CODES:

1 = NATURAL  2 = FRESH  3 = 1 YR PLUS

4 = 1 YR PLUS (Enter % of NEEDLES RETAINED)

SPECIES CODES:

| | | |
|---|---|---|
| 081-ICEDAR | 015-WHITE FIR | 098-SITKA SPRUCE |
| 041-PO CEDAR | 263-W HEMLOCK | 431-CHINKAPIN |
| 242-WR CEDAR | 264-M HEMLOCK | 361-MADRONE |
| 204-DOUG FIR (INLAND) | 070-W LARCH | 631-TANOAK |
| 205-DOUG FIR (COAST) | 108-LODGEPOLE PINE | 351-RED ALDER |
| 017-GRAND FIR | 122-PONDEROSA PINE | 310-VINE MAPLE |
| 022-NOBLE FIR | 117-SUGAR PINE | 888-MIXED |
| 011-SILVER FIR | 119-WHITE PINE | 999-ROTTEN |
| 019-ALPINE FIR | 093-ENGLE SPRUCE | |

R6-5150-126 (6/79)

Caution: On some copies of this form, the species codes for Tanoak and Red Alder are wrong. The form above has the correct codes.

# Debris Potential Summary Form (Tons/Acre)

EXAM. NO. _____ DATE _____ SUMMARIZED BY _____

UNIT NAME _____ COMPARTMENT NAME _____

| | SPECIES----- | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | DEBRIS----- | <3 | 3, >3 | cull | <3 | 3, >3 | cull | <3 | 3, >3 | cull | BREAKAGE |
| | DBH GROUP<br>1.0 – 2.0 | | | | | | | | | | |
| | 2.0 – 3.0 | | | | | | | | | | |
| | 3.0 – 4.0 | | | | | | | | | | |
| | 4.0 – 5.0 | | | | | | | | | | |
| | 5.0 – 6.0 | | | | | | | | | | |
| | 6.0 – 7.0 | | | | | | | | | | |
| | 7.0 – 8.0 | | | | | | | | | | |
| | 8.0 – 9.0 | | | | | | | | | | |
| | 9.0 – 11.0 | | | | | | | | | | |
| | 11.0 – 13.0 | | | | | | | | | | |
| | 13.0 – 15.0 | | | | | | | | | | |
| | 15.0 – 17.0 | | | | | | | | | | |
| | 17.0 – 19.0 | | | | | | | | | | |
| | 19.0 – 25.0 | | | | | | | | | | |
| | 25.0 – 30.0 | | | | | | | | | | |
| 30+ | 30.0 – 40.0 | | | | | | | | | | |
| | 40.0 – 50.0 | | | | | | | | | | |
| | 50.0 – 60.0 | | | | | | | | | | |
| | 60+ | | | | | | | | | | |
| 30+ TOTAL | | | | | | | | | | | |
| GRAND TOTAL | | | | | | | | | | | |

## SPECIES CODES FOR SLASH HAZARD APPRAISAL DATA FORM

| COMMON NAME(S) | SCIENTIFIC NAME | SPECIES CODE | ALSO USE FOR |
|---|---|---|---|
| Subalpine fir | *Abies lasiocarpa* | AF | |
| Douglas-fir | *Pseudotsuga menziesii* | DF | |
| Engelmann spruce | *Picea engelmannii* | ES | |
| Grand fir | *Abies grandis* | GF | |
| Lodgepole pine | *Pinus contorta* | LP | |
| Ponderosa pine, Yellow pine, Bull pine | *Pinus ponderosa* | PP | |
| Whitebark pine | *Pinus albicaulus* | WBP | Limber pine |
| Western hemlock | *Tsuga heterophylla* | WH | Mountain hemlock |
| Western larch, Tamarack | *Larix occidentalis* | WL | Alpine larch |
| Western redcedar | *Thuja plicata* | WRC | |
| Western white pine | *Pinus monticola* | WWP | |

---

ENTER NUMERICAL QUANTITIES AS THREE CHARACTERS. EXAMPLES:

123 12. 012 1.2 001 .12 .01 NOTE: 12. AND 012 ARE EQUIVALENT SO ARE 1.0 AND 001

THREE-CHARACTER FORMAT APPLIES TO ALL ENTRIES, INCLUDING MERCHANTABLE TOP STANDARD, DEBRIS LOADING, DOWN-WOODY FUEL LOADINGS, DUFF LOADING, SLOPE, AND MOISTURE

---

CHARACTER-COUNT FOR PROJECT IDENTIFICATION INCLUDES BLANK SPACES. EXAMPLES:

THIS LINE COUNTS 30 CHARACTERS

AND THIS LINE COUNTS 34 CHARACTERS

# SLASH HAZARD DATA FORM



PROJECT IDENTIFICATION (up to 48 characters) _____ (1-48)

UTIL. STD. _____ (1-10) (11-13) ∿ INCH MERCANTABLE TOP (blank for precommercial thinning)

HELICOPTER OR SKYLINE SKIDDING _____ (1-10) (PUNCH 1-10) GROUND-LEAD SKIDDING _____ (OMIT CARD) NO SKIDDING _____ (OMIT CARD) (check one)

LOP DEBRIS _____ (1-10) (PUNCH 1-10) YES _____ (OMIT CARD) NO

MOISTURE % (1-8) STD. _____ (OMIT CARD) 1 Hr _____ (11-13) 10 Hr _____ (14-16) 100 Hr _____ (17-19) 1000 Hr _____ (20-22) Duff _____ (23-25)

1. ENTER LOADING, TONS/ACRE, BY SPECIES AND D.B.H. CLASS, FROM DEBRIS-PREDICTION RESULTS

| Field | | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | D.B.H. classes in inches | | | | | | | | | | | | | | | | |
| (1-4) SIZE | (6-8) SPP. | (11-13) 0-1 | (14-16) 1-2 | (17-19) 2-3 | (20-22) 3-4 | (23-25) 4-5 | (26-28) 5-6 | (29-31) 6-7 | (32-34) 7-8 | (35-37) 8-9 | (38-40) 9-11 | (41-43) 11-13 | (44-46) 13-15 | (47-49) 15-17 | (50-52) 17-19 | (53-55) 19-25 | (56-58) 25-30 | (59-61) 30+ |
| −3IN | | | | | | | | | | | | | | | | | | |
| 3+ IN | | | | | | | | | | | | | | | | | | |
| CULL | | | | | | | | | | | | | | | | | | |
| −3IN | | | | | | | | | | | | | | | | | | |
| 3+ IN | | | | | | | | | | | | | | | | | | |
| CULL | | | | | | | | | | | | | | | | | | |
| −3IN | | | | | | | | | | | | | | | | | | |
| 3+ IN | | | | | | | | | | | | | | | | | | |
| CULL | | | | | | | | | | | | | | | | | | |
| −3IN | | | | | | | | | | | | | | | | | | |
| 3+ IN | | | | | | | | | | | | | | | | | | |
| CULL | | | | | | | | | | | | | | | | | | |
| −3IN | | | | | | | | | | | | | | | | | | |
| 3+ IN | | | | | | | | | | | | | | | | | | |
| CULL | | | | | | | | | | | | | | | | | | |
| CULL | BKG | | | | | | | | | | | | | | | | | |

2. ENTER LOADINGS, TONS/ACRE, BY SIZE CLASS, FROM DOWN-WOODY INVENTORY RESULTS

| Field | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | SOUND | | | | ROTTEN | | | | |
| Size class | 0-.25 | .25-1 | 1-3 | 3-6 | 6-10 | 10-20 | 20+ | 3-6 | 6-10 | 10-20 | 20+ | DUFF |
| DOWN FUELS (1-10) | (11-13) | (14-16) | (17-19) | (20-22) | (23-25) | (26-28) | (29-31) | (32-34) | (35-37) | (38-40) | (41-43) | (44-46) |

For duff loading, multiply duff depth in inches by 14.5 except for ponderosa pine. For PP duff multiply by 10.0 instead.

GRASS LOAD (1-10) _____ (1 IN CC 11) HEAVY _____ (CC 11 BLANK) MODERATE _____ (OMIT CARD) LITTLE OR NONE (check one)

SLOPE PCT (1-10) (11-13)